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DIV. INSECTS

DIV. ENTOMOLOGY

THIRTEENTH REPORT

OF THE

STATE ENTOMOLOGIST

OF

MINNESOTA

TO THE GOVERNOR

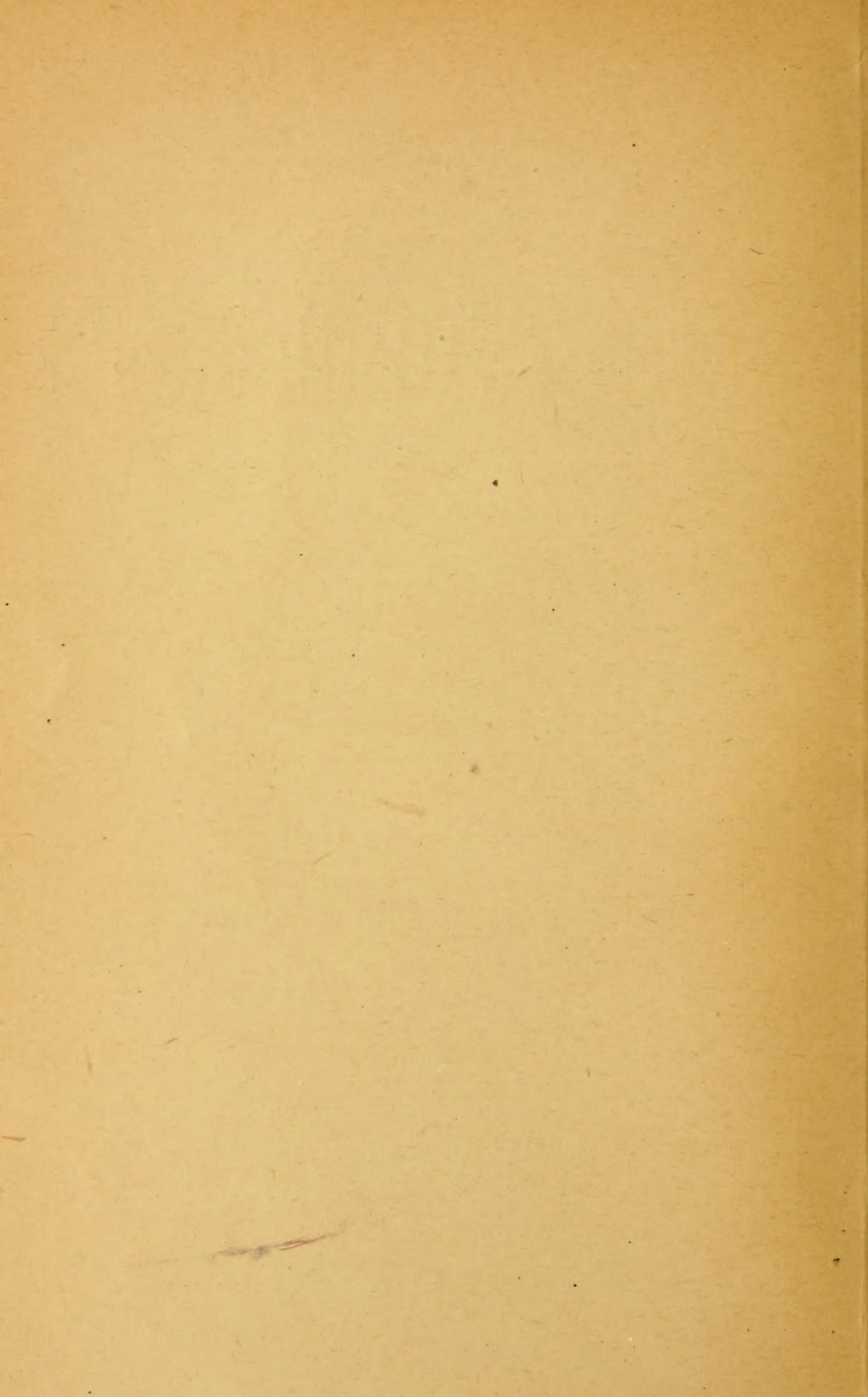
FOR THE YEARS 1909 AND 1910

SEVENTH REPORT OF F. L. WASHBURN

AGRICULTURAL EXPERIMENT STATION

ST. ANTHONY PARK, MINN.

DECEMBER, 1910



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DECEMBER 1, 1910.

PRESS OF
H. C. BOYESON CO.
SAINT PAUL

LETTER OF TRANSMITTAL

STATE EXPERIMENT STATION,

ST. ANTHONY PARK, MINN.,

DECEMBER 1, 1910.

To His Excellency, A. O. Eberhart, St. Paul, Minn.

DEAR SIR: I herewith present the Thirteenth Report of the State Entomologist of Minnesota, covering work of this office and insect conditions during 1909 and 1910. For the sake of economy this report is now printed biennially. In addition we print from time to time and mail to farmers and fruit growers circulars of information and press bulletins, planning to have these reach them at the time when most needed, and thus be more helpful than if we delayed publishing until the issuing of the printed report. This plan appears to work satisfactorily.

GENERAL INSECT CONDITIONS DURING 1909 AND 1910: During 1909 native species of grasshoppers were abundant and troublesome in various localities throughout the state, complaints reaching this office from St. Cloud, Fertile, Crookston, McIntosh, and from localities in Otter Tail and Norman Counties. These complaints were prophetic of the trouble in store for us in 1910, the present year, in which grasshoppers have been more troublesome, causing decided loss locally, than for many years. These are native varieties, and while they have not possibly noticeably reduced the yield of grain, in the state at large, they have, in certain localities, cut down the crop of farmers from two-thirds to four-fifths, some individuals having become utterly discouraged in consequence. The output of flax, however, has been markedly diminished this year, which diminution is due almost entirely to the attacks of grasshoppers. Where practicable your entomologist has helped deserv-

ing farmers by furnishing them oil for use in hopperdozers. The furnishing of free oil, however, is too great a tax upon the slender resources of the State Entomologist, and cannot be continued unless some more material financial aid is granted by the state. It has been suggested that a grasshopper emergency fund be created, and kept upon the State Auditor's books for use in times of crisis. The trouble has come, in every case, from the existence in the neighborhood of large tracts of unused or reverted land, held by residents or non-residents, who either cannot or will not cultivate the same. The subject of grasshoppers, and the need of a more stringent grasshopper law is discussed elsewhere in this report. The greatest damage which came under our observation occurred in Wilkin County, though Polk, Clay, Norman and other counties also suffered. See page 10.

Cutworms have been so abundant and injurious during the spring of 1910 that we have made them the subject of our colored plate. Later in the season the wheat head army worm, *Heliothis diffusa*, appeared in enormous numbers in about thirty different localities, and not only destroyed the seed of timothy, but injured this crop for hay, and in many cases marched to neighboring crops, causing wide-spread havoc. This pest, which is very rarely troublesome, originated this year in Minnesota in timothy fields which had been allowed to lie too long unplowed. The army worm cited has been so injurious that it is made the subject of a special article in this report. See pages 1 and 4 and figures 1, 2 and 3 on colored plate.

The annual visitation of the different kinds of grain lice was in evidence in 1909, not resulting, however, in any serious injury.

No complaints have reached us of the Corn Root Worm which, however, is so abundant and injurious in Iowa that Professor Holden, of Ames, Iowa, reports that the 1910 corn crop of that state was damaged to the extent of \$20,000,000.

Shade trees have suffered both in 1909 and 1910 from the pests common to them, and the year just closing is noteworthy on account of the quite wide-spread destruction of some of our finest city trees. Elms have been killed by the elm tree borer, and maples attacked in many cases and ruined by one or more species of Buprestid beetles which affect such trees. Both in 1909 and 1910 the Oak Pruner, the Fall Web Worm, the White-marked Tussock Moth, the Locust Borer, Bronze Birch Borer, Birch Leaf Skeletonizer, and Leaf Folders have been in evidence. (See page 103.)

The usual quota of fruit tree pests has been noted, and the increase of two scales, namely, the Oyster Shell Scale of the apple, and the Scurfy Scale, is particularly to be remarked upon. The Buffalo Tree Hopper and the Apple Leaf Hopper have also been the subjects for complaints.

We also have to report complaints of serious injury from the Strawberry Weevil. We are beginning to receive inquiries regarding the Onion Maggot and Onion Thrips. Buffalo Gnats, "Black Flies," were very bad in the spring of 1909.

A typhoid epidemic occurred in towns on the Minnesota Iron Range in the fall of 1910, and your entomologist was called upon by members of the State Board of Health to visit the localities in question for the purpose of aiding them in determining to what extent the common house fly, or Typhoid Fly, as it is now called, was responsible for the spread of the disease. An abstract of our report on conditions there, with photographs, is printed on pages 135-142.

SPECIAL EXPERIMENTS: Under the direction of the Office of Experiment Stations at Washington we have been working in 1909 with the Apple Leaf hopper, above mentioned; also a grain insect, *Macrosiphum granaria*, and a clover insect, *B. funebris*, which reduces the yield of clover seed.

Special experiments also have been conducted against the Cabbage Maggot, which attacks not only cabbage but cauliflower, radishes and turnips; against several species of stalk borer very destructive in gardens, and spraying apples and plums to prevent injury by plum curculio. We have also tested the possibility of poisoning fruit trees by the use of arsenical sprays.

Our special work in 1910 in the line of experimentation has been the study of the clover seed midge, known as *Bruchophagus funebris*, an insect which lowers our product of clover seed materially every year, probably from 40% to 50%, and whose life history is not fully understood. In this connection we are working under the direction of the Agricultural Department at Washington, and have made considerable progress in our knowledge of its habits, which knowledge will help us in combating the pest in this state. We have also carried on special experiments with various insecticides, and are beginning work with the Wheat Joint Worms.

INSECTARY: Three hundred and fourteen different experiments were carried on in the insectary during 1909. This number represents a large series in connection with the clover seed insect, referred to above, and also the leaf hopper. There has also been insectary work with the Stalk Borer, several species of borers working on shade trees, and many insects have been reared from the larval to the perfect stage, thus giving us an opportunity of studying their life histories and determining their names. Two hundred and fourteen insectary experiments is the record for 1910, which really represent a much larger number included as "sub-experiments."

EXPERIMENTAL GARDEN: A piece of land granted the entomologist for experimental work, upon a part of which the insectary is located, has again demonstrated its usefulness, and the director and a committee for the purpose has allowed the entomologist some land adjoining the present site for future work. The entomologist has been promised sufficient land for experimentation, should the present garden be needed for building space.

SPRAYING EXPERIMENTS: The assistant entomologist, Prof. A. G. Ruggles, carried on in 1909 a number of experiments in spraying, and in summarizing the results of the work, it may be said with certainty that three sprayings for plums and apples, with three pounds of arsenate of lead in fifty gallons of Bordeaux mixture, the first spraying to take place before the fruit trees bloom, the second just after the bloom has fallen, and the third ten or twelve days later, will insure a very large per cent of sound fruit, protecting the fruit and the tree from the attacks of the Plum Curculio, Codling Moth, and also a majority of plant diseases. See page 143.

The crop of plums and of apples was practically a failure in 1910, and we have, therefore, been unable to push work further in this direction.

STATE INSECTICIDE LAW: At the thirty-sixth session of the State Legislature a bill, (H. F. 173) for an act to prevent deception in the sale of Paris green and other insecticides, introduced by Mr. Horton, became a law. The enforcement of all provisions of the act was placed with the State Dairy and Food Commissioner. A federal law to the same effect, but including all states and territories was created by Congress in the same year. The latter also imposes several penalties for the shipment of any adulterated insecticide or fungicide. See page 101.

CORRESPONDENCE: During 1909 the entomologist dictated 2,149 letters, in large part answers to inquiries regarding insect pests. In addition 774 circular letters were mailed, and about 2,000 circulars and press bulletins, exclusive of the station mailing list. This does not include the Twelfth Report, which was sent out to approximately 700 addresses in addition to copies mailed to comply with individual requests. Bulletin 112, which was practically a duplication of the Twelfth Report, was sent from the Experiment Station mailing office to something like 15,000 addresses. In 1910 we mailed 2,461 letters, answering inquiries, in addition to over 1,000 circulars.

LECTURES: In 1909 a few lectures were given by the entomologist in the northern part of the state (notably one on December 1st to farmers at Red Lake Falls) in regions which had suffered that year from attacks of grasshoppers. In 1910 one lecture was delivered January 14th at Duluth, and lecture appointments for the next eight weeks have already been made, as follows: December 6th, State Horticultural Society, Minneapolis; December 12th, Boy Scouts, Minneapolis; December 21st, Agricultural College, Crookston; December 28th, Entomological Society of America, Minneapolis meeting; January 21st, Boys' Club, Minneapolis. Lectures were given, both in 1909 and 1910, to students in the Farmers' Short Course at the Agricultural College.

Publications.

—1909—

- Jan. 20—"Cabbage Maggot on Radishes, Work of 1908."
- Feb. 12—Twelfth Report of State Entomologist, "The Apple Leaf Hopper and Other Injurious Insects of 1907 and 1908".
- Feb. 20—Circular No. 16, "San Jose Scale Possibilities in Minnesota".
- May 4—Press Bulletin 31, reprint, "Suggestions to those contemplating spraying".
- May 25—Circular No. 17, "Household Insects: A, The House Fly and the Clothes Moth".
- Nov. 15—Circular No. 18, "The Museum of the Division of Entomology at the Minnesota Agricultural College".

—1910—

- Feb. 1—Circular No. 19, "The Danger of Introducing the Gypsy and Brown-tailed Moths into Minnesota".
- April —Nine thousand insect charts.

- June 1—Vol. 1, No. 1, Minnesota Insect Life.
 July 1—Vol. 1, No. 2, Minnesota Insect Life.
 Aug. 1—Vol. 1, No. 3, Minnesota Insect Life.
 Aug. 25—Press Bulletin No. 39 (Circular No. 20), "Grasshoppers and Army Worms in Minnesota".
 Sept. —Pamphlet descriptive of figures on chart "Some Minnesota Insects and Useful Birds".

NURSERY INSPECTION: In 1909 sixty-two nurseries were inspected; the sum of \$234.74 collected as legal fees and expenses was turned into the State Treasury, according to law. In 1910 fifty-eight nurseries were examined, much more time being spent on each nursery than in the preceding year. The sum of \$263.73 received, was handed the State Treasurer, and receipt received therefor. See page 59 for detailed account of inspection of nurseries.

INSPECTION OF STOCK IMPORTED FROM EUROPE INTO MINNESOTA. See page 59.

INSECT CHARTS ISSUED BY THE STATE ENTOMOLOGIST TO THE PUBLIC SCHOOLS OF THE STATE. See page 123.

SAN JOSE SCALE. See page 67.

INSECT COLLECTIONS; HYMENOPTERA OF MINNESOTA: Our collection of Minnesota insects has been materially increased this year, and we have made a special effort to secure a systematic collection which will aid in a popular treatise on the bees, ants and wasps of Minnesota planned by this department.

"MINNESOTA INSECT LIFE": This publication is a new feature of our work. It aims to place before farmers and fruit growers of the state *timely* items on the prevention of insect injury during the spring and summer. The mailing list of this publication is growing constantly. It is in no sense a bulletin. We issued this year three numbers—one on the first of June, one on the first of July, and one on the first of August. We aim, in future, to mail the first copy not later than April 1st, which will, among other things, give our agriculturists proper information regarding spraying.

EXHIBITS: In March, 1910, at the first State Conservation Congress, held in the Auditorium at St. Paul, this division displayed an instructive collection of insect models, illustrations of insect injury, life histories, spraying machinery, nozzles and insecticides.

The entomologist was in Europe at that time, and the exhibit was prepared and installed by Assistant Professor Ruggles of this department. We also had, as in previous years, exhibits at the State Fair both in 1909 and 1910.

HONORARY OFFICES: During 1909 and 1910 the Minnesota Entomologist has held the office of President of the American Association of Horticultural Inspectors, and has recently been honored by being elected President of the American Association of Economic Entomologists for the ensuing year.

ACKNOWLEDGMENTS: The work of the past two years has been materially helped by the faithfulness and efficiency of my office force and field assistants. I wish to express my appreciation of their loyalty. I have lost one good man in Dr. Franklin, who resigned to accept an extremely flattering offer in Massachusetts. His place has been filled by Mr. Theodore Urbahns, formerly in Government service, who comes to us with excellent recommendations. Mr. A. G. Ruggles is still with me as chief assistant. Mr. E. W. Stafford has been employed in the insectary. The state press, as always, has been helpful in placing before the public timely notices regarding insect pests. While this department does not hesitate to publish what it deems important, we greatly deplore the practice prevalent among many reporters of writing up fictitious "scares" for the sake of making good stories. As exhibiting the help of the press in connection with our work, and also showing in what demand publications from this department are, when it is generally known that such publications are for distribution, this office received, after inserting notice of publication in various county paper, but by no means in all, over five hundred requests for a bulletin on spraying, within a period of six weeks.

In connection with our inspection of European nursery and florist's stock sent to this state, the collectors of U. S. Customs, both at St. Paul and Minneapolis, have been very helpful in that they have notified us immediately upon the arrival of foreign shipments. See page 59

Finally, I wish to thank you, Sir, as well as others at the State Capitol, for most courteous and kindly treatment in connection with the work of the entomologist.

Respectfully,

F. L. WASHBURN.

FINANCIAL STATEMENT,* FISCAL YEAR, AUGUST 1, 1908, TO
AUGUST 1, 1909.

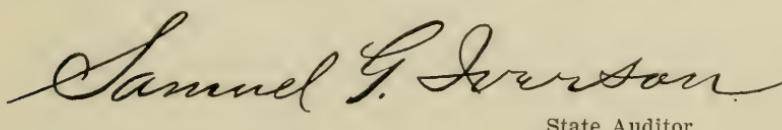
Apiary supplies	\$ 15.99
Assistant Entomologist (salary)	466.64
Clerk and accountant	400.00
Cuts, etchings, electros, colored plates, etc., for Annual Report, bulletins and circulars	423.82
Drawings, etc., for reports, bulletins and circulars	79.49
Experimental garden supplies	104.99
Field notes on insects	25.41
Field and traveling expenses of Assistants.....	207.73
Freight and express	73.62
Insectary apparatus	26.55
Insectary and field assistants	364.36
Insecticides	33.87
Labor	152.99
Laboratory supplies and apparatus.....	82.07
Microscopes (Greenough dissecting) for insectary	222.00
Models of insects for lectures, and insect cases.....	42.50
Nursery inspection expenses	214.91
Office and laboratory assistants	306.90
Office supplies and furnishings	74.77
Periodicals, publications, library cards, etc.....	147.31
Photo supplies	75.99
Plants for experimental garden	49.90
Postage Correspondence, Biennial Report Circular	156.00
Printing Annual report, circulars etc.....	1,008.25
Spraying machinery	18.00
State Entomologist's traveling expenses	156.47
Stationary, etc	91.35
Substitute stenographer	22.50
Telegrams	13.08
Telephone	65.00
 Credit Nursery Inspection	\$ 214.91
Entomologist's Fund	5,000.00
 \$5,122.46	\$5,214.91
	5,122.46
 Balance on hand	\$ 92.45

*Bills covering details of the above are on file in the State Auditor's Office.

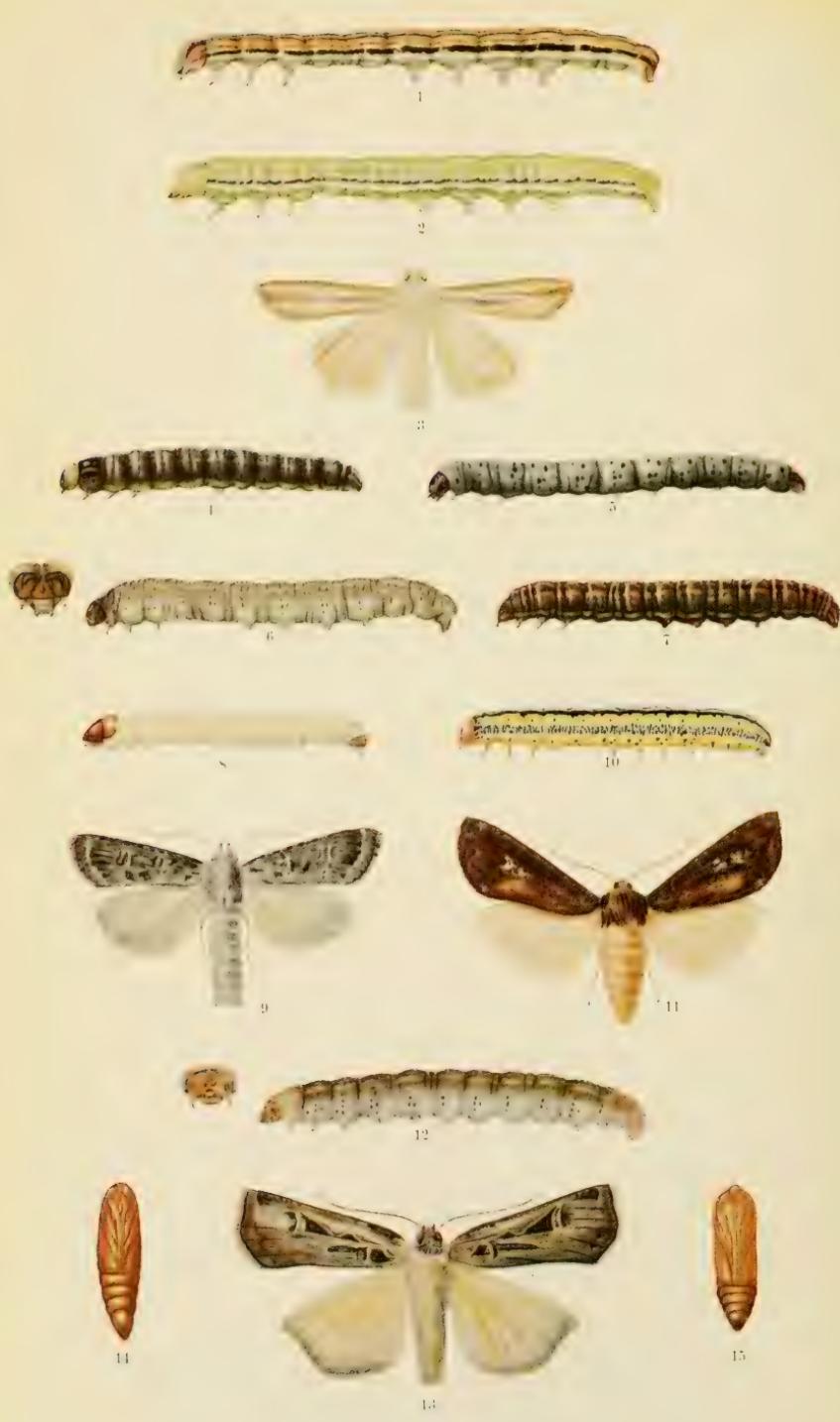
FINANCIAL STATEMENT* FICAL YEAR AUGUST 1, 1909 TO
AUGUST 1, 1910.

Apiary	\$ 13.25
Assistant Entomologist (salary).....	1,649.99
Assistant Entomologist, (Traveling expenses)	70.32
Assistant in Federal Inspection	135.00
Cuts, etchings, etc., for Press Bulletins and Circulars	11.39
Drawings for rep. buls, circulars, etc	35.00
Express and Freight	40.82
Field work	36.50
Insectary assistant (field expenses)	104.60
Insectary chief (field expenses)	84.55
Insectary supplies	30.02
Insecticides	33.54
Kerosene for combating grasshoppers	6.00
Labor	131.47
Laboratory supplies	203.03
Lumber	8.56
Nursery inspection	202.31
Office assistants	151.52
Office supplies	32.35
Photos, negatives, prints, etc.....	33.79
Plants for garden	52.85
Printing (bulletins, circulars, etc.)	44.75
Publications, periodicals, press notices, etc.....	109.24
Secretary and clerk	1,001.00
Spraying machinery	311.00
Stamps for correspondence, circulars, etc.....	69.00
Stationery	103.58
Substitute stenographer	10.00
Telegrams	18.59
Telephone	60.00
Traveling expenses	209.35
	<hr/>
	\$5,003.07
Balance on hand Auggust 1, 1909	92.45
Fund	\$5,000.00
Nursery inspection	234.74
	<hr/>
	\$5,327.19
	5,003.07
Balance on hand	\$ 324.12

*Bills covering details of above on file in the State Auditor's Office.
The above account has been examined by me and found correct.



State Auditor.



INJURIOUS INSECTS OF 1909 AND 1910

BY F. L. WASHBURN.

CUTWORMS.

EXPLANATION OF PLATE:

Figs. 1 and 2—Wheat-Head Army Worm, *H. diffusa*, Walk., much enlarged, and showing variations in color.

Fig. 3—Moth of the same.

Figs. 4, 5, 6 and 7—Different Cutworms, collected in the vicinity of St. Anthony Park; died before reaching maturity, hence not identified.

Figs. 8, 9 and 15—Caterpillar, Moth and Pupa of *Hadena devastatrix*.

Figs. 10 and 11—The Zebra Caterpillar, or Painted Mamestra and its moth, *Mamestra picta* Harris.

Figs. 12, 13 and 14—Larva, Moth and Pupa of the Cutworm known as the Subgothic Dart, *Feltia jaculifera*.

We are indebted to Dr. J. B. Smith for identification of the above imagoes. Riley's account of *H. albilinea* probably applies to *H. diffusa*, the latter being commonly regarded as *albilinea* and was so figured by Riley.

Cutworms, represented here by several species, have been so extremely troublesome in 1910, that we have made them the subject of a colored plate in this report, including also the Wheat-Head army worm, *Heliophila diffusa*, Walk, which has been locally very destructive, and also the Zebra caterpillar *Mamestra picta*, and its moth; which, while not a cutworm in the strictest sense, belongs to the same family, *Noctuidae*.

The abundance of cutworms this year may have been due, in a measure, to the cold weather cutting down the weed growth which started in the abnormally warm weather of the early spring of 1910, obliging them to turn their attention more completely to cultivated crops. Complaints of cutworm injury began to reach us in May of the present year, and a few letters were received as late as August. There were more than twice as many complaints in 1910 as in the preceding year, and among the localities affected were Brainerd,

Atwater, St. Paul, Ada, Hibbing, Hastings, Grove City, Kimball, Duluth and Sauk Center; showing the generally unusual distribution of these pests over the state. Several species were probably responsible for the injuries. Those shown upon our colored plates were, for the most part, numerous; but they by no means represent all the varieties present during the two past years.

Two instances well illustrate the unusual abundance of this pest in 1910: A gardener in Minneapolis brought us something like fifty or sixty cutworms (species not determined at the time) which he had dug from the soil along a row of onions, not more than fifty feet long; while a member of our staff dug up from about a small piece of golden glow, not more than two feet square, last spring, thirty to forty cutworms.

Cutworms are the larval forms of moths belonging to the family known as *Noctuids*, or Owlet Moths. The first name was given this family because they are particularly night-flyers, most of them remaining concealed during the day; and the second name, on account of the fact that their eyes shine at night, in the presence of a light, to which, by the way, many of the species are attracted. Living normally in sod land, what could be more natural than that when deprived of this by farm cultivation, they should attack the crop immediately following. They may be, therefore, very severe on crops following sod. The larvae, like the moths, work at night, and conceal themselves, either in the ground an inch below the surface or under some protecting material, in the early morning. Both the moths and their larvae are fond of sweets; and this fact is made use of both by collectors in catching the moths and by the farmer and gardener in killing the "cutworm" itself. The larva, when full grown, averages in length about one and one-half inches, and is, as a rule, dull colored, with or without obscure markings (see colored plate). This full-grown larva burrows into the soil a short distance, and turns into a brownish or reddish-brown or mahogany-colored pupa (see Figs. 14 and 15, colored plate). These pupae may winter over, when formed late in summer, or give rise to moths in August and September, which lay their eggs at that time on various plants, or on the ground near their food-plants. The larvae which hatch in late summer or fall, winter over in some concealed situation, and are ready for business in the spring.

While many birds prey upon cutworms—and although they are eaten by some other insects, and are the victims of parasitic forms, to say nothing of diseases bacterial or fungoid—nevertheless we

have to take active means to combat them if we wish to save our crops. This division has found poisoned bait, made of bran mash sweetened with cheap sugar, or syrup, or molasses, and made decidedly green with a liberal application of Paris green, to be a very good remedy in a garden. A tablespoonful of this should be put at frequent intervals among the plants subject to attack; not, however, nearer than twelve inches to the plant; for, in case of rain, the Paris green might be washed against the roots, and would injure or kill the plant. The Paris green should be mixed with the bran when the latter is dry. Thorough cultivation is an aid. Pieces of shingle or board, placed at intervals over the garden, serve as traps under which the cutworms hide toward morning, and enable them to be found and killed. Frequently the depredator will be found in the morning, within an inch or so of the plant cut, buried an inch under the soil. Young plants, when not too numerous, like cabbage, cauliflower, etc., when first set out in a small garden, should be protected by paper or tin, or a barrier of some sort, which should extend into the ground an inch or so, and two or three inches above the surface. This can be removed when the plant becomes so tough as not to invite attacks from the cutworm. On large acreages, fall plowing and thorough cultivation is perhaps the most practical treatment. Cutworms, as we said above, are always bad the next year after sod, since they normally live in such situations. Some farmers, in 1910, reseeded their grain fields with flax on account of the former being destroyed by cutworms.

The family *Noctuidae* is an enormous one. Professor Lugger, my predecessor, left a list of two hundred and thirty-five different species of the group, captured partly at St. Anthony Park, and partly at Duluth. Of this list, something like forty-five species are typical cutworms. Therefore, farmers can hardly speak of "the cutworm."



Fig. 1. A Cut worm and its work.

A WHEAT-HEAD ARMY WORM.

(*Heliothis diffusa*, Walk.) An Enemy of Timothy.



Fig. 2. The Wheat-head Army Worm, *A. diffusa*, *a*, *a*, worms feeding on head of grain; *b*, eggs under a leaf sheath; *c*, *d*, two views of egg, enlarged. Below, the male moth. After Riley. Courtesy of J. B. Smith.

It is probable that this army worm was present and increasing in 1909, though its numbers at that time were not sufficient to attract the attention of the farmers. The drouth of 1910 was probably also in part responsible for the devastation of the current year.

These army worms (see Figures 1 and 2 of colored plate) vary in color from green to a very dark brown, or even blackish, but almost invariably show characteristic stripes on sides and back.

About the first of July of the present year the note of alarm in connection with this unusual visitor was first sounded by a telegram received from Detroit, Minn.—“Worms damaging corn and grain badly here. Please send man to investigate.” July 5th came another one from Heron Lake—“Green worms working on wheat, oats and rye. Send man to introduce method of extermination. Condition serious.” Following these, and all in July, came complaints from Russell, Canby, Walnut Grove, St. James, Elbow Lake, Windom, Cottonwood, Revere, Marshall, Worthington, Hills, Tyler, Battle Lake, Ashby, Murdock, Stillwater, Ruthton, Hendricks, and elsewhere.

Men were of course dispatched, upon receipt of the above telegrams, to the places asking for help; and we were kept busy during midsummer in going from place to place and doing what we could to instruct farmers in the methods necessary to overcome the trouble. We found in every instance that the original infestation came from old timothy fields —fields that had been allowed to stand for from six or seven to ten years without feeling the plow, and offering ideal conditions for the increase of the pest.

They are a quite different species from the army worm which is familiar to the majority of Minnesota farmers. *H. unipuncta*, and which is commonly known as "The Army Worm."



The Wheat-head Army Worm, the species under discussion as causing damage this year, is not a frequent visitor in Minnesota, or anywhere else for that matter; and it may be many years, barring its possible occurrence in small numbers in 1911, before we are troubled by it again. It is widely distributed over the United States, as far west as the Great Plains. When full grown, at which time the caterpillar is about one and a fourth inches long, they go into the ground two or possibly three inches, and turn into mahogany-colored pupae about three-fourths of an inch long, resembling closely Fig. 14 of the colored plate, from which the pale brownish or "clay yellow" moths (Fig. 3 of colored plate) emerge later. The female moth lays its eggs on the leaves (timothy, grasses, grains, etc.); which eggs hatch into the above-named worms. We found many of them entering the pupal stage shortly after the middle of July; hence it would seem that it is two-brooded, or at least partially so in Minnesota; but it would appear that the second brood of worms, coming late, after harvest, might meet with difficulty in finding food.

It is not out of the way to say that at least four-fifths of the timothy seed crop in central and southern Minnesota has been destroyed this year by this species of army worm, and the timothy materially injured as a hay crop. A conservative farmer near Marshall, estimated the loss on the hay alone as equaling one-fourth of the crop, or a loss of about \$2 on every acre. In the vicinity of Otter Tail, it was roughly estimated that they had nearly destroyed 200 acres. Around Battle Lake, about 1,000 acres were badly damaged. A farmer at Windom states that he lost \$150 on his timothy crop. From Russell we received a report that from 1,200 to 1,500 acres of timothy was practically destroyed. From another section, 95 acres of timothy was reported as a total loss. A statement received from Heron Lake (July 13) was to the effect that the

Fig. 3. Head of wheat injured by the Wheat-head Army Worm Original.

seed of 75 per cent. of the timothy acreage had been destroyed. From St. James, same date: "Timothy is entirely destroyed, absolutely worthless for seed. Timothy crop has been damaged from 20 per cent to 25 per cent for hay. Timothy will cut from three-fourths to one and one-fourth tons per acre." From Tyler, "The timothy crop of seed in this section is practically all gone * * * and what hay we get is short and thin." From Windom, July 15th, "Twenty acres (of timothy) are a total loss." About July 7th, A. T. Sexe, near Hills, reported that this army worm had about completely destroyed his forty-acre field of timothy. Under date of August 27th, 1910, Northrup, King & Co., in a letter to the entomologist, in which they speak of the serious loss in sections where most of the timothy seed is harvested, state that timothy seed had nearly doubled in value. This, however, was in a large measure due to the drouth of last summer. Conditions practically identical with those in Minnesota prevailed in parts of Iowa and the Dakotas.

Mr. Urbahns was sent to Worthington, Minn., July 12th. He found army worms had done much damage to timothy by feeding upon the heads. The injury was most severe on high sandy soil. The larvae were rapidly pupating on above date, and their work for the season was over. He met fifty farmers more or less interested in the control of this pest, and carried on discussions concerning combative measure.

In every case investigated, as stated above, we found that the pest had its origin in old timothy fields that had been allowed to run a number of years, four or more, without being plowed. After the timothy heads are eaten, the worms turn their attention to oats, wheat or corn, traveling in an army from one field to another, hence their name.

They appear to be somewhat subject to the attacks of parasites; and are undoubtedly, in common with other caterpillars, devoured by predaceous



Fig. 4. Head of barley injured by Wheat-head Army Worm.
Original.

beetles, by birds, and die on account of fungous or bacterial diseases. Nevertheless, these factors simply serve to keep them within bounds, and it is absolutely necessary, when a farmer is confronted with a horde of these worms stripping his timothy field, and preparing to march to grain fields, to know what to do and to realize that *whatever is to be done must be done without delay in order to be effective*. Fall plowing and the rotation of crops, sovereign remedies for many field-insects, are valuable here. If farmers would plow up their timothy fields at least once in three years, it would be a help in connection with this or any other insect which found there an undisturbed breeding-ground. Another year, quite possibly, this army worm might not originate in timothy, but be found beginning its depredations on some other crop. Its repression, therefore, appears to be dependent upon proper farm practice. In cases of serious infestation, as in the present instance, when a farmer's crop is threatened by these worms, and the land is in a condition to allow it, he should plow one or two deep furrows across the line of march of the worms, the steep side of the furrows toward the crop to be protected. The worms collect in the furrows and can be killed with kerosene, or better, with crude oil. If post-holes eight or ten inches deep are made at intervals in these furrows, they form traps into which the worms fall. Or, the ditch or furrow may be partially filled with straw, which may be wet with kerosene and burned after the worms have collected thereon. A farmer can spray a broad strip about the worms, or across their line of march, with Paris green, at the rate of two or three pounds in 100 gallons of water; or arsenate of lead (better than Paris green) at the rate of four or five pounds in 100 gallons of water. Sometimes it is practicable to drag a heavy roller over the advancing worms. Dusting dry Paris green on vegetation about the worms may be resorted to. Fields where they are entering the soil to go through the resting stage should be plowed—harrowing is not sufficient. Co-operation in the attack is necessary; for there might remain on one man's place enough worms to lay waste the entire neighborhood later on, if every one did not take preventive measures.

The presence of this worm on cured hay does not poison it for stock, as some farmers have supposed.

From July 11th to 13th, Mr. F. J. Crider of this division was in the field. His report in detail follows:

CONDITIONS AT WORTHINGTON: I was taken out into the field around Worthington by Mr. Jones. Spent half a day in this way; talked to several farmers of the community in regard to the work of the army worm. Dam-

age from the insect was confined entirely to timothy; did not go into grain. The seed crop of timothy was a total loss. Most farmers cut the timothy for hay, but state that its hay-value was greatly lessened by the work of the insect—20 to 30 per cent was the average estimated loss on hay. The worm not only destroyed the head, but in many cases stripped the plants of their leaves. The greater amount of damage was reported from *old* timothy fields that have not been broken in from five to ten years. Some farmers did not use their hay for any purpose, but left it standing in the fields. It now presents the appearance of naked stems, destitute of heads or leaves. I searched, and found several live pupae just beneath the surface of the ground; but the majority of the insects seemed to have already changed to the adult stage, as was evidenced by the great number of empty pupal cases that were found. I counted as many as a half-dozen empty pupal cases in an area of sod six inches square, and among those only one live pupa. On the whole, however, there are yet a great many pupae still in the timothy sod.

Mr. Jones is very much interested in the work of eradicating the army worm. He expressed a willingness to co-operate with the Station in any way possible. Says that he shall be glad, and wants to bring the farmers in closer touch with the Station, in a way that will benefit them. He will distribute literature, etc., among the farmers of the community, if such is desired.

CONDITIONS AT WINDOM: Called on Mr. Brown, County Auditor; talked with several farmers of the community, and went out into the fields around Windom. About the same conditions were found as at Worthington. From the standpoint of seed, the timothy crop is a total loss. Most farmers have cut the fields for hay, but state that its value was greatly lessened by the work of the worm. No damage was reported concerning grain-fields. The work of the insect was confined to timothy alone. Found some live pupae in the fields in timothy sod, and a great many pupal cases, showing the adult had already emerged. Mr. Brown was very pleasant, and wished to render the Station any assistance possible.

CONDITIONS AT ST. JAMES: Went out to Mr. Otto Uhlhorn's place; walked through the fields all the way out. Mr. Uhlhorn and other farmers stated that the damage from the army worm was confined to timothy, except on the edges of grain-fields adjoining timothy. The timothy crop is a total loss for seed, and 25 to 30 per cent loss for hay. Most farmers used the crop for hay, a few fields were not cut at all; fields of old timothy sod were damaged worst. New timothy fields, near old sod, affected worse than entirely new fields or fields away from old sod. Insect appeared when timothy came into blossom, and remained until the crop was destroyed. Heard of one man at Darfur, seventeen miles from St. James, whose oats were attacked to some extent by the insect. Charley Stark, Mountain Lake, had a field of timothy for seed, that was entirely stripped by the 17th of July.

Looked for pupae in the fields, and found the same conditions as at Worthington and Windom. Several live pupae were found, but mostly abandoned pupal cases.

Mr. E. W. Stafford was sent to Heron Lake on July 6th, and makes the following report:

Examined conditions at Heron Lake. Army worms have been working on timothy which is becoming mature and being cut. They now are migrating to other crops, e. g., wheat, oats, barley, corn. These larvae have destroyed most of the timothy seed in the environs of Heron Lake. As timothy is ready to cut, maximum damage is already done to that crop. Rye is much of it cut, so not damaging it. One farmer's oats so badly infested that he cut prematurely for hay. Recommended plowing furrows and use of kerosene and crude oil. Placed larvae on kerosene can almost dry; died in 45 to 60 seconds. Examined field of corn belonging to Mr. Pratt; across road, a badly infested timothy field, on farm of Mr. Smith. On farm of C. P. Fiske little infestation. In Pratt's field the rows near timothy were badly infested with army worms. Attacked central shoots, ate holes in leaves, and ate on edges of the leaves. Degree of infestation decreased as one advanced away from edges of field. After about 35th row, little or no infestation. Looked at corn rather late in the evening, and found many larvae on the ground. It rained the day before examination was made, and Mr. Fiske said larvae on his oats were not as plentiful as the day before.

Visited the farm of Mr. Geo. Reynault, and found army worms migrating from cut timothy to other crops. Attacked oats, wheat and barley equally badly. At edge of fields, found great numbers; ten feet in, found a few, and at thirty feet found none at all.

It is said that some timothy fields have been left as long as ten years. Where there was no timothy there was no trouble with the worm. Much of the grain will soon be harvested, so will be out of danger. Many farmers are enthusiastic about the idea of using crude oil in the furrows. Price is lower, and it will not evaporate so readily nor penetrate into the soil.

The worms do more damage to wheat than to other crops, as they often cut off stems at base first thing, then the whole head falls off. In oats, the larva consumes one kernel at a time. I did not find any on flax, clover, alfalfa, nor on the swale grasses.

Went out with P. B. St. John to farm of John Maxner. Timothy being cut, corn adjacent. First forty rows rather bad. He had put Paris green on two rows, with little or poor results. I examined the stubble for larvae, but found none.

Went to Shaeffer's farm. He had cut a furrow about two feet from edge of field, and left strip as trap. This got covered with larvae, and with a pail he collected a large quantity, which he killed.



The Wheat-head army worm.

GRASSHOPPERS.

During the summer of 1910 grasshoppers have worked more havoc than for years before. Numerous complaints were received in 1909, but it would seem that these complaints merely indicated that the "hoppers" were gathering their armies, as it were, and preparing to work all the havoc they could in 1910. The accompanying map indicates by crosses the counties from which complaints regarding grasshoppers were received during the above-mentioned two years, and also the number of localities in each county from which we received inquiries; by far the largest number representing complaints sent in during the season just passed. These crosses represent by no means the entire number of inquiries or reports of injury, since in almost every case many complaints came from one town. The circles shown mark localities suffering in 1910 from the attacks of the Wheat-head Army Worm.

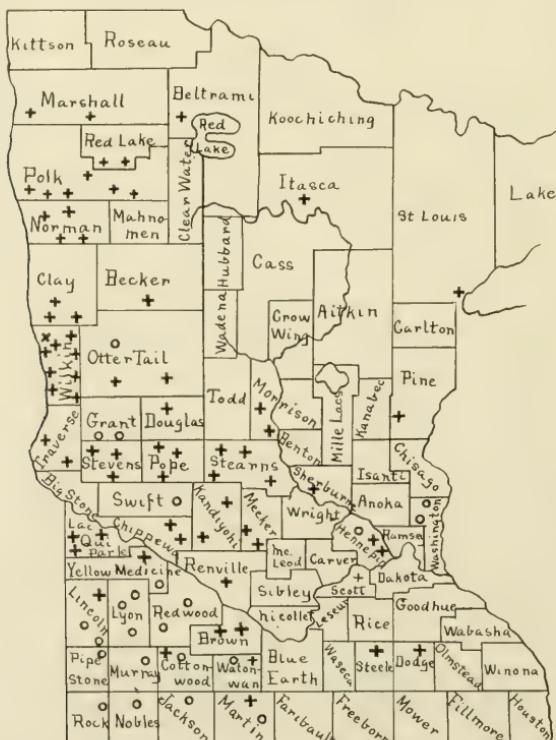
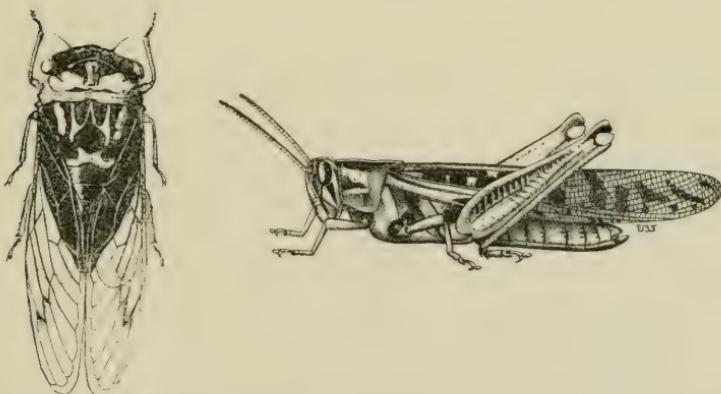


Fig. 5. Map of Minnesota. Crosses show localities from which complaint was received of grasshopper injury. Circles denote localities reporting Army Worm injury.

With all due appreciation of the help given this division by the state press, perhaps no insect is used more than the grasshopper, by ambitious young reporters, to make a good story with scare head-lines. What made it more aggravating in this instance was the continual confusing of the Seventeen-year Locust or "Harvest Fly"—which is a sucking insect and not a true locust or grasshopper—and the grasshoppers or true locusts, which have been so unpleasantly prominent this year. To illustrate, we quote one or two absurd statements from county papers. The Tribune of Stewart, Minn., under date of August 19, 1910, says:

"But within the past week several farmers have seen the genuine red-legged, Seventeen-year, or Rocky Mountain locusts flying high in the air."

On January 19, 1910, the Standard, of Albert Lea, had some reference to a visitation of Seventeen-Year Locusts. The entomologist, in a desire to straighten the matter out, sent a letter to the editor. Note how the editor treated it in his issue of February 2, 1910:



Figs. 6 and 7. Cicada or Harvest Fly, commonly called locust, and a true locust, commonly called "Grasshopper."

"No Fear of Grasshoppers."

"The Standard is in receipt of the following letter, which ought to dispose of all predictions and guesses concerning the pest mentioned."

"EDITOR STANDARD: I note, that in your issue of January 19, you have a reference to the coming of the Seventeen Year Locust. No prediction regarding this insect has gone out from this office at any time; and, as you say, quotations of this kind are frequently unfulfilled. It seems a pity that things of this sort are spread over the country, unnecessarily alarming citizens, and causing more or less of a reflection upon the entomologist.—F. L. Washburn, State Entomologist."

There is no prospect at present of an invasion of the Periodical Cicada or Seventeen-year Locust, though many states to the south and southeast of us have periodical appearances of this insect, which passes the seventeen years (or thirteen years in the case of the 13-year form) of its larval life in the ground. It is not out of place, perhaps, to take this opportunity to advise farmers to avoid accepting unauthorized statements regarding insects, appearing in the daily or county papers, and to read most carefully any communication *authoritatively signed*; for sometimes, as in the above example, the heading and the information contained in the letter are quite at variance.

One will note, upon looking at the accompanying map, that grasshoppers were pretty well distributed over the state in 1909 and 1910, drawing this conclusion from reports and complaints received through the mails, but that they became much more numerous, and consequently much more destructive, as one went west and northwest from St. Paul; and that in the Red River Valley, throughout its entire length, they were particularly severe. These are all native locusts or grasshoppers, as we all call them, as far as seen; and, when they are bad at all, loss is bound to be felt in the area indicated. In other words, in a farming locality which one might call a pioneer region, in that it is in the immediate vicinity of large tracts of untilled land, we will always have times of more or less trouble with grasshoppers.

Although the yield of flax has been materially reduced, the entomologist does not believe that the entire output of grain by Minnesota has been materially diminished in 1910 by this year's attack. But that is not the point at issue at present. The fact that

many of our hard-working and deserving farmers in the counties indicated have lost materially, anywhere from a fifth of a crop to their entire crop production, and that some are so thoroughly discouraged as to think of abandoning farming in Minnesota, should interest state authorities sufficiently to cause them to inquire into the reason for these periodical invasions, and find a remedy. The reason is not hard to find. Large tracts of land which have reverted, or which have never been cultivated, held by speculators or others, offer ideal places for the egg-laying of this pest; and there are thousands of acres of such land in the western part of this state, where owners are absolutely indifferent to the fact that farmers, endeavoring to make a living on the outskirts of these pest-breeding acres, have to make prodigious efforts to secure crops, and frequently fail altogether, because they cannot cope successfully with the hordes of grasshoppers pouring in upon them from the above-mentioned uncultivated acres. We have a grasshopper law in this state; but, inasmuch as the owner or lessee of such dangerous land is not obliged by this law to pay for the plowing, it is ineffective. We have the names and addresses of many of the owners or holders of such land, and a list of their property in Wilkin County; and have written some, only to find—knowing as they do, the weakness of the law—absolutely indifference, carried to such an extent in one or two cases that they did not even take the trouble to answer our letters. There are thousands of acres of such land in Wilkin County alone—the undisturbed breeding-ground of millions of grasshoppers. In Andrea Township alone we have a record of over 8,000 acres of such land. Manifestly a county cannot stand the expense of plowing these tracts, even if sufficient men could be secured to properly do the work.

Two ways are open, which would seem to offer at least partial relief for this deplorable situation; one, the work of the individual farmer, properly directed by experts, aimed at keeping the hoppers off his growing crops, and to that end using intelligently not only well known methods, but others which may be discovered through investigations of entomologists; and second, the creating

of a more stringent law—something like the grasshopper law of North Dakota, perhaps,—obliging large land-owners to bear the expense involved in fighting this insect. We are heartily in favor of such a law for this state. We want also to have, for the next two or three years, an expert in the field constantly, located at a central point in what we might call “the grasshopper district,” and not only trying various new methods available for the farmer, some of which we have in mind at present, but also going from place to place where needed by farmers, and instructing them how to properly apply the best known measures of protection. Such a man would be immensely useful to farmers in a stricken locality, beside being in a position, from a constant careful study of the situation, to make valuable suggestions along new lines of control. Further, we have recommended to the Governor and the State Auditor the advisability of keeping upon the Auditor’s books a sum which does not revert, but is always available in times of crises, to meet emergencies along these lines. For a time there was such a fund, consisting of several thousand dollars, left over from early grasshopper days. This has reverted long since, and at present there is absolutely no fund to draw upon if we ever have a sudden and destructive visitation of grasshoppers. The writer has suggested that a fund of from \$12,000 to \$15,000 be kept upon the books, for emergency use only, and its expenditure properly safeguarded by a board or commission. This plan has met with the approval of the State Auditor, who states that he sees no reason why such a bill would not receive the approval of the Legislature.

In April of the present year (1910) a report was received, from a farmer living at Granite Falls, that the unusually warm weather in March had brought out the young grasshoppers, and that they had been killed by the freeze in April. This would have been good news if it had been actually the case in all parts of the state. Unfortunately, grasshoppers were found hatching in large numbers early in May, when all danger of cold weather had passed; and our hopes, based on earlier reports, if we had such hopes, were doomed to disappointment; for, in the eight years and more we have served Minnesota, we have never had so much trouble and so much complaint as in 1910. Twenty or more afflicted farmers in Wilkin County were in correspondence with this division on account of this trouble, and we have had men in the field assisting them, showing them how to construct and use hopperdozers.

North of Wilkin County, near Crookston, Fertile and Beltrami, and also in Otter Tail County and elsewhere, practically the same conditions existed. In some cases we furnished oil free to farmers, for use in hopperdozers. There is no law directing the entomologist to do this, but he looked upon the existing conditions as an emergency, and wished to do all he could to assist men endeavoring to raise crops under these trying conditions. Perhaps fifty hopperdozers were in daily use in one neighborhood in Wilkin County.

Letters complaining of grasshoppers began to reach our office early in June, rapidly increasing in numbers during that month, and continued arriving in large bunches until late in August and even into September; and this division of the Experiment Station was kept busy, both in visiting different localities and in correspondence.

We mentioned above the furnishing of free oil to needy farmers who required it for hopperdozers (see account below). In this connection it should be said that the State Entomologist's fund is not sufficient to meet any such demand, and particularly would this be the case if we were deluged with the pest. It is to be hoped, therefore, that some special legislation may be enacted this winter, covering the needs in question.

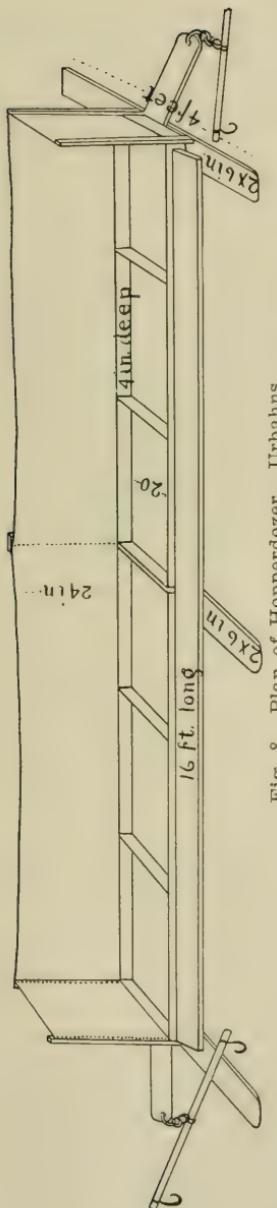


Fig. 8. Plan of Hopperdozer. Urbahns.

KEROSENE ALLOWED FARMERS FOR COMBATING GRASSHOPPERS
IN 1910.

			gals.	\$
June 18	W. W. Rowles, Everdell.....	25		3.25
June 18	W. & F. Fuder, Foxhome.....	23½	"	2.94
June 23	Chas. Reber, Foxhome.....	50	"	6.25
June 24	F. E. Sutter, Foxhome.....	10	"	1.25
June 24	H. J. Marsh, Foxhome.....	5	"	.63
June 25	T. S. Olson, Foxhome.....	18	"	2.25
June 26	Henry Hendrickson, Everdell.....	25	"	3.25
June 27	P. Stonehart, Rothsay.....	45	"	5.85
July	A. M. Gamme, Beltrami.....	20	"	3.00
July	C. K. Lukman, Beltrami.....	25	"	3.75
July	B. O. Lindberg, Beltrami.....	20	"	3.00
July	F. W. Lenz, Beltrami.....	20	"	3.00
July	C. Nordlum, Beltrami.....	20	"	3.00
July 6	O. K. Bjerkebek, Breckenridge.....	10	"	1.50
July 8	O. K. Bjerkebek, Breckenridge.....	10	"	1.50
July 9	Ole Toso, Rothsay.....	15	"	2.25
July 9	Nils Sudahl, Rothsay.....	20	"	3.00
July 11	Boyer Bros. & Co., Beltrami.....	15	"	2.25
July 11	Phil. Heider, Foxhome.....	20	"	2.50
July 13	F. M. Hunter, Breckenridge.....	25	"	3.75
July 29	A. Merrill, Gentilly.....	6	"	.75
July 29	Edw. Lanetot, Gentilly.....	10	"	1.25
July 29	John Demarais, Gentilly.....	3	"	.38
July 29	Patrick Kelly, Gentilly.....	25	"	3.13
July 29	Rock Valley, Gentilly.....	14	"	1.75
July 29	J. B. Gufault, Gentilly.....	20	"	2.50
July 29	Dan'l Sully, Gentilly.....	10	"	1.25
July 29	Gilbert Brault, Gentilly.....	8	"	1.00
July 29	Pierre Dufault, Gentilly.....	9	"	1.13
July 29	Geo. Plant, Gentilly.....	3	"	.38
July 19	O. O. Reed, Rothsay.....	20	"	3.00
July 19	Lewis Heggan, Rothsay.....	5	"	.75
July 30	Gilbert Braatelin, Rothsay.....	15	"	2.25
July 30	Hans Christianson, Rothsay.....	43	"	6.45
July 30	O. P. Weston, Rothsay.....	18	"	2.70
July 30	Anton Foss, Rothsay.....	4	"	.60
Aug. 3	Ed. Steiner, Rothsay.....	15	"	1.95
Aug. 3	John Longfelt, Rothsay.....	25	"	3.25
Aug. 3	John Rolin, Rothsay.....	25	"	3.25
Aug. 4	H. Knudson, Everdell.....	25	"	3.25
Aug. 12	H. J. Marsh, Everdell.....	25	"	3.25
Aug. 13	A. Sitar, Breckenridge.....	25	"	3.75
Aug. 14	August Danielson, Rothsay.....	5	"	.65
Aug. 15	Hugo Koppe, Rothsay.....	15	"	1.95
Aug. 17	Benesh & Pierce, Breckenridge.....	50	"	7.00
Aug. 18	Benesh & Pierce, Breckenridge.....	50	"	7.00



Fig. 9. Hopperdozer at work. Original.

The grasshoppers causing the damage in 1910 have been, as far as we have seen, the Red-legged Locust or grasshopper, the Lesser Migratory Locust or grasshopper, the Two-striped Locust or grasshopper; the latter being extremely numerous, compared with its



Fig. 10. Hopperdozer at work, front view. Original.

numbers in former years. Some farmers thought, because they saw swarms of locusts in the air, that they must have been the Rocky Mountain form; but we saw no evidence of this species, and will have to call attention to the fact that the Lesser Migratory Locust, as well as other forms, probably, have this habit in common with the Rocky Mountain variety. Further, farmers must bear in mind that any grasshoppers can be destructive in proportion to their abundance. They do not need to come from the Rocky Mountains in order to be dangerous. Friends of the writer, entomologists who work in Colorado and Montana, stated in 1909 and also in 1910, that for some time they had been unable to find, in their representative states a trace of the form known as *The Rocky Mountain Locust, Caloptenus spretus*; which species, by the way, is very closely allied to our common and destructive Lesser Migratory Locust. While in the field in Wilkin County, July 6th and 7th, 1910, we found the Two-striped Locust very abundant, for the most part full-grown and some mating. Of the Red-legged and Lesser Migratory there were more young than adults. At these dates also we occasionally saw quite large swarms high in the air, and coming apparently from the West.

Observations.

In addition to field work with the farms in 1910, we have made some laboratory observations which may be of interest, and tried experimentally a solution (arsenite of soda) in successful use in South Africa.



Fig. 11. Another view of working hopperdozer. Original.

I. We have found that young hoppers, freshly hatched, can live from four to five days without food under trying conditions—a fact which is not particularly encouraging to the farmers.

2. A very young hopper will average, in traveling on hard soil, about one foot every five minutes. They make about one foot at a jump, rest awhile and jump again. On soft soil their rate of travel is very much less than on hard—only a very few inches every five minutes.

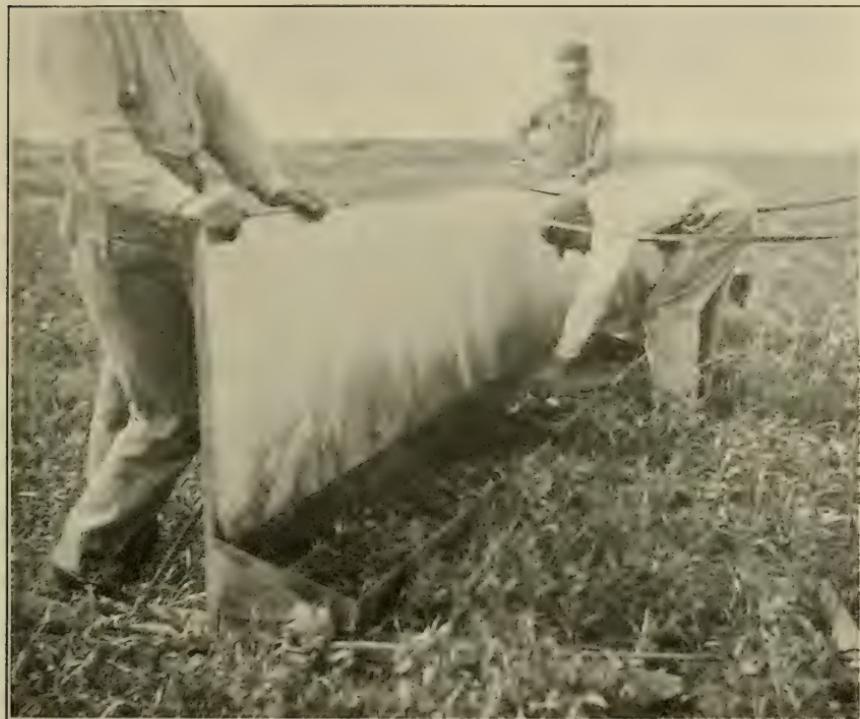


Fig. 12. Scooping out the dead hoppers. Original.

3. The accompanying drawings, made from living specimens by Miss Iris Wood, show the successive stages in the hatching of a grasshopper, and its freeing itself from the enveloping membrane, or so-called "amnion." Fig. 1, breaking through the egg-shell; Fig. 2, a few minutes later; Fig. 3, still later; Fig. 4, freed from the egg-shell, but still wrapped in the "amnion"; Fig. 5, kicking off the "amnion." The length of time required in this process varied from about four minutes to fifteen, possibly dependent upon the amount of moisture present in the soil containing the eggs.

Quoting from Miss Wood's notes, figure 3 was drawn at a time when "a strong movement was observed between thorax and abdomen." Almost no independent movement of legs until the pellicle or "amnion" is cast off. This (casting off of the amnion) began to take place immediately when the hopper was free of the egg-shell (Fig. 4). The pellicle split across the back of the thorax, and, by movements more of the body than the appendages, was passed forward over the head. The antennae and mouth parts were drawn out of the pellicle; then the first and second pair of legs were drawn out, and in about three minutes the entire amnion (pellicle) was cast off, but clung several minutes to the posterior end of the abdomen. As soon as the hind legs were free, the hopper turned over and began to walk, at first using only the two front pairs of legs, the tibiae and femora of the hind legs being close together and raised, and the body dragged along by the front pair."

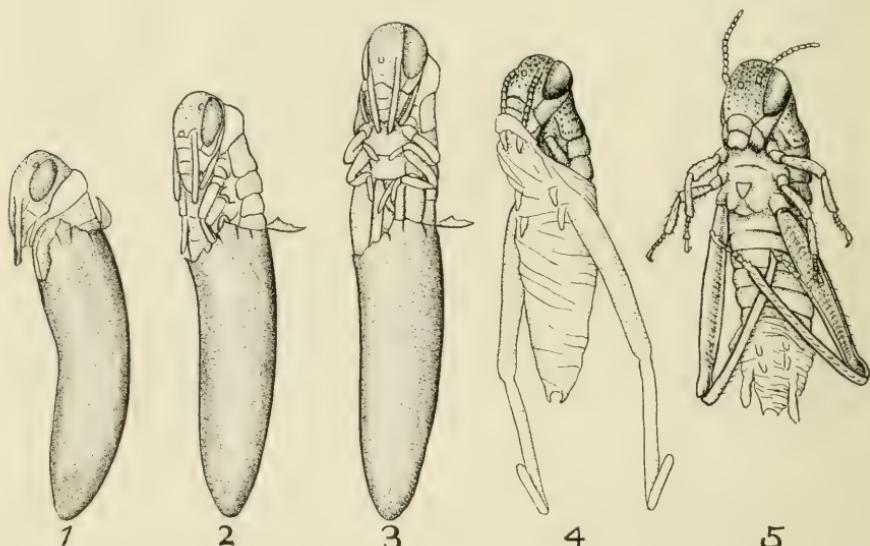


Fig. 13 Five stages in the hatching of a grasshopper. Original.

Remedies and Preventive Measures.

(1) THE PLOW AND THE HARROW are the most important enemies of grasshoppers. A faithful use of the plow on the part of all farmers in a neighborhood, and all land-owners, will materially reduce the number of this pest in any given locality. As is well known, grasshoppers lay their eggs in late summer and early fall, in pockets made by the female, an inch or an inch and a half deep. These

eggs hatch in the spring, in normal years between May 1st and May 15th, or thereabouts. These pockets are turned over by the plow, preventing the escape of most of the newly-hatched hoppers. Consequently late fall or early spring plowing (five or six inches deep) is one of our best remedies against these insects. Evidently, there must be co-operation on the part of all farmers in a neighborhood, in this important matter. Where deep plowing is impossible, a faithful harrowing would help shallow plowing, thus more effectively breaking up the egg-masses and exposing the eggs to the varying changes of the weather. The plowing of roadsides in the late fall or early spring, where there is serious infestation, is desirable.

(2) PLOWING UNDER YOUNG HOPPERS: Young hoppers just hatching can sometimes be taken care of by plowing them under, beginning on the outside of the field in which they are hatching, and plowing toward the center. This turns many under, and by depriving them of almost all food, makes it much more difficult for them to reach the edge of the plowed piece where they might damage a valuable crop.

(3) CRIDDLE MIXTURE: When grasshoppers are young, or half grown, a poisonous bait, known as the Criddle Mixture, has proved effective in many parts of the country. This consists of one part Paris green and about 100 parts of fresh horse-manure, by measure. Enough water is added to make the mass soft without being sloppy. It can be taken to the field on a wagon or stone-boat, and scattered about by means of a paddle. One might think that turkeys and other fowls, in picking over such material for bits of undigested grain, might be poisoned. This, in our own experience, does not seem to be the case. It would probably be dangerous if used in proximity to small chickens.

(4) BURNING YOUNG HOPPERS: It is sometimes possible to burn over a tract swarming with young hoppers, and thereby save an adjoining crop. This burning, however, must be done with care, and the farmer must decide whether he is doing more harm to his hay crop than he is getting benefit thereby.

(5) POISONED BRAN: Garden truck to which chickens do not have access may be protected to some extent by mixing bran with water to the consistency of chicken feed, adding Paris green until the mixture has a greenish color (2 parts Paris green to 25 parts bran, by measure), sweetening with cheap syrup or molasses, and

strewing the same amongst the plants, taking care not to place it directly against a plant. Spraying garden vegetables and other plants with arsenate of lead, 4 pounds to 100 gallons of water, would also serve to protect them.

(6) HOPPERDOZERS: These, though not giving complete satisfaction, are regarded as one of the best helps; in fact, almost the only help, for a farmer upon whose crops the grasshoppers are pouring from adjacent unplowed fields. Hopperdozers are made of sheet iron, generally 16 feet long (though they may be shorter), and the drawing which accompanies this article illustrates a general



Fig. 14. Experimenting on small scale with arsenite of soda. Original.

plan. The upright part behind may be canvas or cloth, or of sheet iron. With the details suggested by Fig. 8 farmers should be able to construct one to suit their needs, and possibly improve upon the plans given. I might say, in this connection, that a horse at each end is better than one horse in the middle. When wanted for use, a little water is placed in the pan and also thrown against the canvas-cover back, if canvas is used. This back is then drenched with kerosene, and about two quarts of the oil are poured on the water in the pan. The machine is driven back and forth over fields of young grain or flax which is being eaten, and bushels of the insects are killed in this way. This work is best done when the day is bright and warm, and before the insects reach full size. Even though a grasshopper may jump out of the pan,—if he has been in the kerosene, he is doomed.

(7) PLOWING A STRIP TO CHECK ADVANCES OF YOUNG HOPPERS: In case a farmer is located next to an immense tract of unplowed land, whereon grasshoppers are hatching in large numbers and threatening to overrun his crops, manifestly he cannot do the impossible—in other words, plow all the reverted or unused land;—but he might plow a strip of this infested land several rods wide, along the side of his own land, thereby forming a barrier which it would be difficult for the very young hopper to cross, and thus giving time to prepare other means, (hopperdozers, for instance) to use against them.

(8) THE MINNESOTA GRASSHOPPER LAW: This is strikingly ineffective, as stated above, and we would do well to follow the example of North Dakota in this respect. The method of procedure under the Minnesota law is as follows:

Complaint of the infested land should be made in the fall, to the State Entomologist, or to the Board of County Commissioners, or both, accompanied by specimens of eggs. The entomologist examines the land; and, if conditions justify it, he recommends to the Board of County Commissioners that the land be plowed. The County Board serves notice on the owner or lessee of infested land, requesting him to plow within a certain time. If he fails to do this, the county plows the land; and, if said plowing benefits him in raising crops immediately after, assesses him to refund the money paid.

It is evident that, under the provisions of this law, the county will have to pay most of the bills for plowing. If our farmers think this law should be made more stringent, and the owner of said property be made to pay for the plowing in any event, it is in their power to make an effort to amend the present law to that end.

The North Dakota law, given below, is more stringent in that the expense of plowing is made a lien upon the land, and the record owner or incumbrancer of said land must pay the cost of plowing.

Revised Code of North Dakota, 1905.

ARTICLE 27.—DESTRUCTION OF GRASSHOPPERS.

Sec. 2108. *Duty of County Commissioners.*—The Board of County Commissioners shall have power, and it shall be their duty, to order the plowing of land, and such other means as they deem expedient, wherever and whenever they deem it necessary to cause the destruction of grasshoppers and Rocky Mountain locust's eggs: and said plowing and other means shall be done at the time and in the manner directed by said Board of County Commissioners by the owner or incumbrancer, if any, of said land immediately after receiving notice thereof from said Board of County Commissioners.

Sec. 2109. *Notice, how and when served.*—Where the owner of the land on which said Board shall have decided plowing must be done for the purposes herein specified, cannot with reasonable diligence be served with notice within the state, it shall be sufficient to serve the said notice by publication thereof for two successive issues in the official newspaper nearest said tract.

Sec. 2110. *Must plow in five days.*—If the owner or incumbrancer, if any, shall fail to plow said tract or tracts as ordered and directed by said Board of County Commissioners, within five days after notice as herein provided, then, in that event, said Board of County Commissioners shall cause said tract or tracts to be plowed, or so much thereof as may be by them deemed necessary, and audit and pay for said work out of the general fund of said County, upon warrant as in other cases made and provided.

Sec. 2111. *Expense a lien upon land.*—Immediately after the said accounts are audited and paid by said County Commissioners, it shall be the duty of the County Auditor to certify to the County Treasurer the amount so expended upon each piece and parcel of land, which certificate shall contain the name of the record owner or incumbrancer of said tract, a true description of said land, the amount paid by the county for plowing done thereon; and the County Treasurer shall thereupon enter said amount against said land as taxes are entered against said land, and the said amount shall constitute a lien upon said land prior to all other incumbrances, and shall bear interest at the rate of seven per cent per annum from date of entry by the County Treasurer, and collection thereof may thereafter be made and enforced in the same manner as delinquent taxes are enforced and collected against real property.

Sec. 2112. *Payment out of general fund.*—When the Board of County Commissioners shall deem the plowing of state land necessary for the purposes herein specified, they shall order the same done, and payment therefor may be made out of the general fund of the county, upon warrant as in other cases provided; provided, however, that no growing crops shall be destroyed under the provisions of this article; provided, further, that when the Board of County Commissioners shall deem it necessary to cause plowing upon government land held by resident claimants, or other means to cause the destruction of grasshoppers and Rocky Mountain locusts, said claimant shall be liable to the county in a civil action for all moneys necessarily expended in carrying out the directions of the Board of County Commissioners for the purpose herein specified.

A Partial List of Reverted Lands in Wilkin County in 1910.

Of all localities this county appeared to be the worst affected during 1910, and since we have found that similar conditions in other counties in the Red River Valley are largely responsible for grasshopper injury, we give here a partial list of these lands in Wilkin, with the names of the owners or representatives of the owners, as reported to us at the County Auditor's office:

ANDREA TOWNSHIP.

Sec. 5, W $\frac{1}{2}$ and SE $\frac{1}{4}$	Mary A. Kenefic, care G. I. Byget, Dayton, Ia.
Sec. 6, SW $\frac{1}{4}$	O. Bertleson et al, Fergus Falls.
Sec. 11, NW $\frac{1}{4}$	J. R. Milliken, N. W. Nat'l Bk., Sioux City, Ia.
Sec. 8, SW $\frac{1}{4}$	Camelia Allen.
Sec. 9, NW $\frac{1}{4}$	M. R. Keeley, Dwight, Ill.
Sec. 17, NE $\frac{1}{4}$	P. G. Shaw, Pocahontas, Ia.
Sec. 18, SW $\frac{1}{4}$	A. W. and Willie Anderson, Stanhope, Iowa.
Sec. 19, NW $\frac{1}{4}$	Paul Rinnengen, Big Bend Land Co., Spokane, Wash.
Sec. 20, NW $\frac{1}{4}$	Howard Espeset, Estherville, Ia.
Sec. 22, NE $\frac{1}{4}$	Jacob Niebles, Fergus Falls.
Sec. 22, SE $\frac{1}{4}$	F. F. Schnetstay, Fergus Falls.
Sec. 26, SW $\frac{1}{4}$	H. G. Richter, Foxhome, Minn.
Sec. 27, NE $\frac{1}{4}$	E. and L. Edwards, Alta, Ia.
Sec. 28, NW $\frac{1}{4}$	G. W. Johnson, Schaller, Ia.
Sec. 28, SW $\frac{1}{4}$	A. R. Kitts, Fergus Falls.
Sec. 28, SE $\frac{1}{4}$	S. A. Rouse, Mankato.
Sec. 29, All	James Espeset, Estherville, Ia.
Sec. 30, E $\frac{1}{2}$, 220 acres	A. R. Kitts, Fergus Falls.
Sec. 36, N $\frac{1}{2}$	W. L. Austin, Rutland, Ill.
Sec. 36, SW $\frac{1}{4}$	F. F. Frost, Des Moines, Ia.
Sec. 36, SE $\frac{1}{4}$	C. F. Livermore, Fairmont, Minn.

AKRON TOWNSHIP.

Sec. 25, NE $\frac{1}{4}$ of NW $\frac{1}{4}$	Sec. 20, Jonas Swenson, Fergus Falls.
Sec. 25, W $\frac{1}{2}$ of NW $\frac{1}{4}$	Sec. 20, Jonas Swenson, Fergus Falls.
Sec. 25, NE $\frac{1}{4}$	Caspar Lien, Fergus Falls.
Sec. 25, SE $\frac{1}{4}$ of NW $\frac{1}{4}$	A. Swenson, Rothsay.
Sec. 25, N $\frac{1}{2}$ and SW of SW	A. Swenson, Rothsay.
Sec. 25, SE $\frac{1}{4}$ of SW $\frac{1}{4}$	Frank Gronnos, Elizabeth.
Sec. 25, SE $\frac{1}{4}$	Andrew Christofferson, Rothsay.
Sec. 30, SE $\frac{1}{4}$	O. G. Felland, Rothsay.
Sec. 30, NW $\frac{1}{4}$	H. G. Heikland, Spencer, Ia.
Sec. 32, SW $\frac{1}{4}$	M. J. Adams, Ames, Ia.
Sec. 33, SW $\frac{1}{4}$	H. J. Olson, Rothsay.
Sec. 8, E $\frac{1}{2}$ of NE $\frac{1}{4}$	E. E. Secor, care Harvey Johnson, Banning, Calif.
Sec. 8, W $\frac{1}{2}$ of NE $\frac{1}{4}$	H. L. Shirley, Breckenridge.
Sec. 8, SE $\frac{1}{4}$	H. L. Shirley, Breckenridge.

TANBURG TOWNSHIP.

Sec. 29, W $\frac{1}{2}$	H. K. Farries, Morning Sun, Ia.
Sec. 30, E $\frac{1}{2}$ of SW $\frac{1}{4}$	J. E. Vincent, Britt, Ia.
Sec. 30, E $\frac{1}{2}$ of NW $\frac{1}{4}$	C. P. Bailey.
Sec. 30, W $\frac{1}{2}$ of NE $\frac{1}{4}$	B. F. Parker, St. Paul.
Sec. 35, NE $\frac{1}{4}$	O. E. Jonsrud, Rothsay.
Sec. 35, SE $\frac{1}{4}$	O. A. Smekop, Rothsay.

MEADOWS TOWNSHIP.

Sec. 24, SE $\frac{1}{4}$	Walter Davis, care F. E. Boone, Breckenridge.
Sec. 24, W $\frac{1}{2}$	J. A. Wigdahl, Rothsay.
Sec. 14, NE $\frac{1}{4}$	W. R. Appleton.
Sec. 14, NW $\frac{1}{4}$	O. P. Burrows, Breckenridge.
Sec. 14, SW $\frac{1}{4}$	F. C. Felts, Fort Dodge, Ia.
Sec. 14, SE $\frac{1}{4}$	F. C. Felts, Fort Dodge, Ia.
Sec. 11, N $\frac{1}{2}$ of NW $\frac{1}{4}$	P. L. Christianson.
Sec. 11, N $\frac{1}{2}$ of NE $\frac{1}{4}$	P. L. Christianson.
Sec. 11, S $\frac{1}{2}$ of NE $\frac{1}{4}$	C. S. Marden, Barnesville, Minn.
Sec. 11, S $\frac{1}{2}$ of NW $\frac{1}{4}$	C. S. Marden, Barnesville, Minn.
Sec. 11, SW $\frac{1}{4}$	C. S. Marden, Barnesville, Minn.
Sec. 11, SE $\frac{1}{4}$	J. F. Buggy, Buffalo Centre, Ia.
Sec. 10, E $\frac{1}{2}$	G. E. Ward, care J. C. Kain, Breckenridge.
Sec. 9, SW $\frac{1}{4}$	R. F. Locke, Rockford, Ill.
Sec. 9, SE $\frac{1}{4}$	Oscar Anderson.
Sec. 21, E $\frac{1}{2}$	Otto Berg.
Sec. 26, NW $\frac{1}{4}$	S. I. Dakin, Breckenridge.
Sec. 20, W $\frac{1}{2}$	E. J. Elliot, care E. G. Everett, Des Moines, Ia.
Sec. 30, SE $\frac{1}{4}$	F. T. Berkey, Breckenridge.
Sec. 12, NW $\frac{1}{4}$	G. W. Barrows, Breckenridge.
Sec. 23, N $\frac{1}{2}$	David Meridith, care J. A. Carlton, Dubuque, Ia.
Sec. 2, NE $\frac{1}{4}$	H. K. Bjargaard, Rothsay, Minn.

Testimony as to Conditions.

The following letter, taken from a large number of similar communications, received in 1910, is fairly indicative of conditions in the Western and Northwestern part of our state.

"Everdell, Minn., June 25, 1910

Mr. F. L. Washburn,

State Entomologist,

St. Anthony Park, St. Paul, Minn.

Dear Sir: Received your order dated June 18th, for 25 gallons of kerosene, and wish to thank you for the same. At the same time I want to call your attention to the fact that the farms I am working have a total of about twelve hundred acres in crop this year, and very likely there will be considerable more needed than the 25 gallons. Will you not furnish more?

The grasshoppers seem to be very numerous, and already it is claimed that they have done and are doing damage. A number of farmers are trying to work against them with the hopperdozers, but the trouble is that there is so much land not being cultivated, growing grass; and it seems that they are very numerous on such land, and the trouble is that they breed on such land and afterwards go to the grain on the cultivated land.

The situation here is fierce. This will be the third successive year that the grasshoppers have been doing damage on a large scale, and if there is anything that you can do through the state to help the farmers in this locality, it ought to be done.

Thanking you in advance for a prompt reply, I am,

Respectfully yours,"

**These Grasshoppers Are Not the Rocky Mountain Locust or
Grasshopper.**

Reference has been made above to the fact that the grasshoppers doing the damage in 1909 and 1910 are not the Rocky Mountain variety; and it was further stated that for some reason the latter form (*M. spretus*) has not been apparent in its usual haunts for many years. In this connection I quote from two letters recently received. One from the State Entomologist of Montana reads as follows:

"I have been collecting Orthoptera in Montana for thirteen seasons now, and have in the collections about 170 species, of which about a dozen are new and undescribed. I have looked particularly for *M. spretus* (Rocky Mountain Locust), but have not taken a single specimen, nor have I taken one that approached this species. This has been particularly interesting to me, in

view of the fact that parts of Montana were formerly considered to be within the so-called permanent breeding grounds. I have collected within this tract as well as outside of it."

The other is from a prominent Colorado entomologist:

"* * * In all of our collecting here during the past twenty years, and it has been quite extensive, we have never taken an example of the Rocky Mountain Locust, *M. spretus*. It is quite a disappointment to me, as I supposed I should certainly have an opportunity to collect this insect many times in Colorado, as Riley had given the permanent breeding-grounds of this insect as extending over a considerable portion of the mountains and foothills and even the plains in this state."

The Lesser Migratory Locust, *M. atlantis*,—one we have with us all the time, capable, as we have seen, of doing great injury when occurring in large numbers, and with somewhat the same habits as the Rocky Mountain form,—is so closely akin to the latter that some entomologists regard them as almost identical, the latter possibly a long-winged variety of the former. The casual observer, noting them in the field, certainly could not distinguish the one from the other.

Mr. Urbahns was sent into the field twice during the summer. His report follows:

First trip made to Foxhome, Minn., June 3rd: Drove out to farms of Chas. Reber, O. L. Fuder, Geo. Sutter and G. W. Greiner. The young hoppers, just hatching, were very abundant, especially so on high sandy waste lands. Burning of meadows and idle lands was practiced wherever possible. In some cases this was done too early to destroy a large percentage of the young hoppers, and in other cases meadows were burned so late as to destroy the grass crop.

A movement was organized to clear the fields of grasshoppers by the use of hopperdozers, through the joint efforts of the farmers of the entire locality. Mr. Chas. Reber was appointed chief in the movement. Promises for the construction and immediate use of eight hopperdozers were secured.

Second trip to Foxhome, in June: Arrangements were made over telephone by which several farmers from south of town were met at the hotel. Two groups of farmers were met in the country at five and eight miles northwest of town. Fields were visited where hopperdozers were in use. The discussions carried on led to several changes in the construction of hopperdozers. Grasshoppers were apparently on the increase, but reports of the work were quite favorable and encouraging. A good number of hopperdozers were in use, and farmers were urged to make greater use of the same.

Rothsay, Minn.: Met four farmers at the home of Ed. Steiner, eight miles southwest, and then drove two miles north to meet eight farmers, who

had gathered at a cross-road to discuss the grasshopper situation. Upon driving one mile farther north, to the home of M. F. Fisher, a meeting was held in the yard, with six farmers present. These meetings were all hurriedly arranged by telephone, through the help of farmers interested in combating insect pests. Farmers were reporting much idle land as a public nuisance, and nearly ten thousand acres were listed. Over eight thousand acres of such land were listed in a single township.

Gentilly, Minn., June: Drove out eight miles to Gentilly from Crookston, and met a group of farmers by appointment. Twelve men interested in combating grasshoppers were present. A few others took slight interest. Reports of abundance of grasshoppers came in from all sides of town, and mostly from fields which were high and sandy.

The situation was discussed, and the most practical methods of control were considered. Grasshoppers in this section were further advanced than they were around Foxhome or Rothsay. Farmers were enthusiastic, and seemed willing to at once take up the work as outlined.

Beltrami, Minn.: I was called to this place by Mr. Johansen. The grasshoppers had destroyed the barley in spots on a field of Mr. C. K. Luhman. A few crude hopperdozers were in use. A gathering of farmers was held on Mr. Luhman's farm, and the work was discussed. Young flax-fields were suffering severely, and the flax was too small to allow of the practical use of hopperdozers. Grasshoppers were mostly about half-grown.

A second meeting was held in the evening, at the home of Ole Olson, with seven farmers present, for the purpose of discussing the construction of a most efficient hopperdozer.

WORK OF 1909 WITH THE APPLE LEAF HOPPER.*Empoasca mali.*

This practically marks the completion of work upon this insect, done under the provisions of the Adams' Act, though some points of interest in its life-history yet remain, inviting further endeavor. The work of 1908 on this species was described in the Twelfth Report of the Minnesota State Entomologist. Summarizing that work we cite the following observations:

1. Fall-laid eggs were not found on any herbaceous plant.
2. The insect winters only in the egg stage.
3. Oviposition in summer was found to occur on the petiole of apple and clover, and probably occurs on other herbaceous plants.
4. List of food-plants was given.
5. Five nymphal stages were reported, covering a period of about twenty-two days.
6. Adults may live fourteen days or over (1907 experiments indicate that they may live thirty days or more).
7. The location and appearance of the winter egg-blister and the contained egg.
8. Remedial measures.

The work of 1909 practically corroborates that of 1908, and adds certain new facts. We add these conclusions and the chief items of work:

9. This species deposits its winter eggs only on perennials, and of perennials, as far as can be determined, only on the apple.
10. There are certainly three, and probably four broods in Minnesota.
11. Manner of emergence of nymphs from egg-blister.
12. Further observations on life-history.
13. Remedial measures.

The work in 1909, as in 1908, was in charge of Dr. H. J. Franklin, and his report in detail is as follows:

Empoasca mali.

Alfalfa and dahlia plants, which had been badly infested with *Empoasca mali* during the summer and fall of 1908, were brought in and placed in the insectary, and kept in the cold part of the greenhouse through the winter. These plants showed the effect of the insect's attack plainly when brought in, and there were many of the insects still on them at that time—October 8th. No specimens of *Empoasca mali* lived through the winter on these plants, and no nymphs emerged from the tissues the next spring (spring 1909). This goes to show that *E. mali* does not deposit winter eggs in the tissues of herbaceous plants, and that the species relies entirely upon the eggs deposited in the blisters found on the bark of perennials. These plants were last examined in the season of 1909 on June 5th, and the plants were at this time more or less dead and dry, except for the new growth which had started up during the month of May, 1909.



Fig. 15. Emergence of nymphs from egg blister. Original.

Apple branches were examined in the orchard early in the spring and were brought in from time to time, and the egg blisters of *E. mali* carefully examined, to find out when the nymphs should begin emerging from the blisters. Nymphs were found in process of emerging on May 24th, the apple leaves at this date being not over one-third developed. Numerous hoppers were found at this date in first and second instars on the apple leaves, and it seemed probable that some of them hatched from the eggs as early as May 21st. Several adults were reared from nymphs hatched from these blisters, and, with one exception, they all proved to be *E. mali*. One undetermined specimen, which was slightly smaller than *E. mali*, was reared from a nymph which emerged from an egg-

blister found on apple, which could not be distinguished in any way from the true egg-blister of *E. mali*. On May 26th Miss Wood made several drawings to illustrate the method of emergence of the *E. mali* nymphs from their egg-blisters. These nymphs emerged through the oviposition opening of the blister, making this opening somewhat larger during the process. When a young hopper begins to emerge from its egg-blister, if the weather is fairly warm, it will often complete the process in a few minutes. One was timed from the moment the vertex of its head appeared until it got clear out of the blister, and it took five minutes. Another was watched from the time it was half-way out until it got entirely free from the blister, and it took about thirteen minutes. The young hoppers were observed to be still emerging from their egg-blisters, in large numbers, on May 26th. The flower-buds of the apple trees were at this time, as a rule, just on the point of bursting into bloom, many of them being already in bloom, and the leaves were from one-third to two-thirds developed. From these observations there is now no doubt that the egg-blisters, which were so carefully measured by Franklin last fall, on the branches of the trees in the orchard, were those of *E. mali*.

Evidence that *E. mali* does not hibernate in the egg stage on other perennials than the apple.

Young leaf-hoppers were gathered from the foliage of elm, white oak, red oak, gooseberry, black birch, linden and white birch, from June 4th to June 10th (at which time the nymphs of the first brood of *E. mali* were developing to the adult condition in the apple orchard) and reared to adults, to see if any *E. mali* had hatched from the winter egg in any numbers on these trees. Adults were reared from nymphs found on all these food-plants, but not one of them proved to be *E. mali*. Currant bushes, box elders, mountain ash, dogwood and some other perennials of less importance were carefully examined for young leaf-hoppers from time to time during the first two weeks in June, and not a single nymph or adult of any species was found. Willows were examined carefully on June 11th, and only a single young leaf-hopper was found. This was reared, and proved to be *E. mali*. Plum trees were also examined carefully on June 7th, and only two nymphs of leaf-hoppers were found. One of these was reared, and proved to be *E. mali*. These observations clearly indicate that *E. mali* seldom, if ever, form winter egg-blisters on any of the kinds of trees examined, namely, elm, white oak, red oak, gooseberry, black birch,

white birch, linden, currant, box elder, mountain ash, willow, dogwood and plum. Even in the case of the two last we have no certain proof that the specimens of *E. mali* reared from them did not first hatch from eggs in blisters on apple trees, and then get blown from the apple to the plum and willow trees, which were about fifty yards distant, though the chances for this, considering the observations made by sweeping on alfalfa, do not seem great.

Notes and Observations on Life-History.

On June 4th trees of the orchard on the flat were examined for this species; no adults were found on the apple trees, though nymphs were present in all stages. The alfalfa field just across the road was examined, to the north of this orchard, and swept with a fine collecting-net, and adults of *E. mali* were found. No nymphs in any stage were found upon the alfalfa at this time, which again shows that this species does not pass the winter in the egg stage on or in alfalfa. The adults found on the alfalfa at this time had evidently come to maturity on the apple trees in the neighboring orchard, and then either flown or been blown by the wind from these trees on to the alfalfa. Counts were made of the number of specimens of adults that were taken by sweeping across the alfalfa field at various distances from the orchard. The field was 164 paces long, extending directly away from the orchard, and the width being about the same (52 paces) from end to end. For each count the width of the field was swept, taking one good sweep of the net at every step. The following table gives the number of sweepings, their distance from the orchard, and the number of *Empoasca* captured.

Paces from Orchard	Number of specimens taken	Sweepings.
9	5	Once across.
130	1	Once across.
13	5	Once across.
21	3	Once across.
40	6	Once across.
60	8	Once across.
80	3	Once across.
100	4	Twice across.
120	3	Once across.
140	2	Once across.
164	3	Twice across.

Making a total of thirteen sweepings across the field, and of 43 adults collected in all.

It will be noticed by this table that there was a slight falling off in the number of specimens toward the further end of the field; but that, aside from this, the *Empoasca* adults were pretty evenly distributed over the entire field. This field of alfalfa was swept several times after this, in a similar manner, with the results given below. On June 9th:

Paces from orchard.	Specimens of adults taken.
10	14
20	7
40	10
60	13
80	7
100	2
140	15
120	11
160	12

Making a total of nine sweepings in all, and 91 specimens taken.

No nymphs at all were found in any of these sweepings. It will be again noted that quite as many specimens were taken at a distance from the orchard as close to it.

On June 11th the field was swept again with following results:

Paces from the orchard.	Number of individuals found.
10	37
20	22
40	19
60	12
80	14
100	12
120	21
140	18
160	13
164	24

Making a total of ten sweepings and 192 specimens.

On June 14th the results of the sweepings were as follows:

No. of paces from orchard.	No. of specimens taken.
10	19
20	23
40	22
60	14

80	14
100	7
120	13
140	14
160	15
165	36

Making a total of ten sweepings and 177 specimens taken.

On June 21st results of the sweepings were as follows:

No. of paces from orchard.	No. of specimens captured.
9	24 adults, 1 young.
13	30 "
20	30 "
40	28 "
60	18 "
80	28 "
100	24 "
120	20 "
140	22 "
160	23 "
165	21 "

Making a total of eleven sweepings and 268 specimens. It should be noted that this is the date on which the first nymph was found in the alfalfa. It was very small, being in the first stage. As the field of alfalfa on which we had made the previous sweepings had been cut down, we had to sweep another somewhat smaller field. The sweeping and counting on this field was done in the same way as in the other field, and the results were as follows, the field being about the same width as the one above, June 25th:

First sweeping across the field.....	55 specimens.
Second sweeping	60 "
Third sweeping	66 "
Fourth sweeping	40 "
Fifth sweeping	54 "

Making a total of five sweepings and 275 specimens. This field was somewhat farther away from any apple trees than was the first one. A few nymphs in the first stage were found. If the results of the sweepings made on these different dates be examined and compared carefully, it will be seen that the individuals taken increased steadily in numbers from the first to the last, with the exception that the sweeping on the 14th of June gave a somewhat smaller number of adults than did that on the 11th. This falling off on the 14th of June, however, is readily accounted for by the

fact that on the 12th, and again on the 13th, there was a considerable amount of rainfall—over half an inch of water falling on the 13th—it being very probable that so much precipitation would kill off the adults in considerable numbers.

On July 9th the alfalfa field which was cut on June 24th was swept, and a number of specimens of *E. mali* were found; the alfalfa since it was cut having attained a considerable new growth.

Sweepings had been made upon clover at about this date (July 9th), and nymphs were found in large numbers. Nearly as many adults were found upon the alfalfa on this date as were found on the clover, in proportion to the number of sweeps of the net. No nymphs, however, were found. The adults had apparently but recently either flown or been blown on to the alfalfa, from the neighboring orchard and from surrounding fields. The absence of nymphs on this field, which had been cut, goes to show that if legumes such as clover and alfalfa be cut just before the eggs for the second brood hatch, much of the infestation for the second brood may be reduced.

On July 24th fields of wheat, rye, oats, barley and flax were examined and hardly any *E. mali* were found in them. On August 24th a large patch of raspberries, at Mr. J. F. Larson's place at Stillwater, was looked over and many of the leaves on the raspberry canes were found to be badly curled as the result of the work of *E. mali*. Many canes had all the leaves curled up, and the adults flew off from these in large numbers when the canes were shaken. On August 26th a large number of apple branches in the flat orchard were very carefully examined, and we could not find any egg-blister of *E. mali*. On September 13th, however, another examination on some of the trees close to the alfalfa disclosed the egg-blisters of *E. mali* present in considerable numbers. It seems probable that oviposition had begun several days before this date. The blisters were not, at this time, nearly so numerous as they were last fall after oviposition had ceased; this showing that adults were still laying at this date (Sept. 13th).

On September 17th the clover fields and alfalfa fields were swept, and it was found that *E. mali* were far less numerous than they had been before this date.

In connection with the work on *Empoasca*, the accompanying chart, constructed by Mr. Stafford, shows the relative abundance of adults and nymphs, indicated by his sweepings of clover upon thirteen dates. This is numerically expressed as follows:

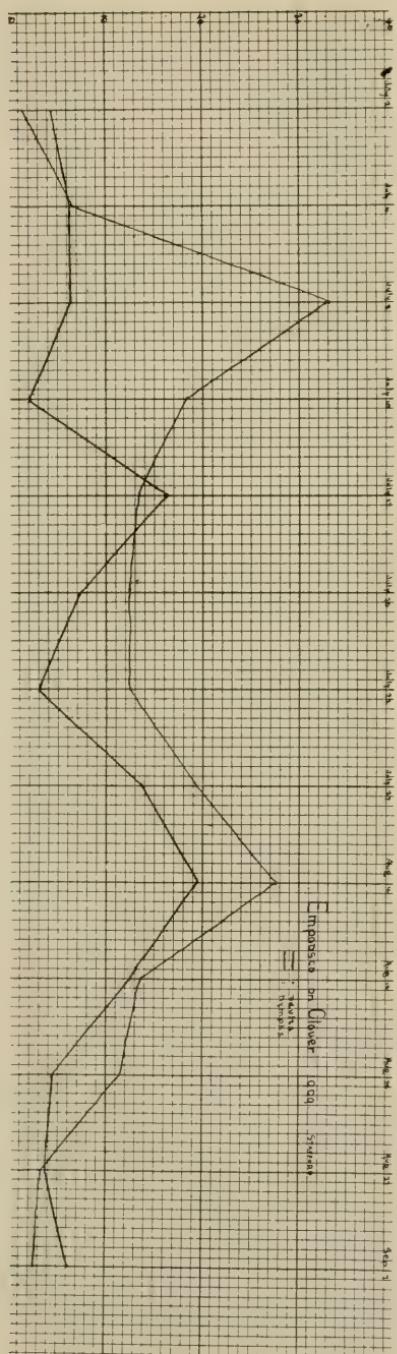


Fig. 16. Chart showing comparative abundance of adult leaf hoppers and nymphs at different dates.
Upper line, nymphs; lower, adults. Stafford.

Date—	Adults	Young
July 2.....	4.3	1.3
July 6.....	6.2	6.8
July 8.....	6.4	33.0
July 10.....	2.0	18.2
July 17.....	16.2	13.4
July 20.....	7.5	12.5
July 22.....	3.0	12.5
July 27.....	13.8	19.6
Aug. 4.....	19.2	27.7
Aug. 14.....	12.6	13.6
Aug. 24.....	4.4	11.6
Aug. 27.....	3.8	3.2
Sept. 7.....	6.0	2.4

Length of Life of the Adult.

Experiments were made to find out how long the adults of *E. mali* live, by taking reared specimens and keeping them on apple twigs in the insectary. We were unable to get any adult to live longer than nine days; but our results, we fear, were deceptive, as conditions in the experiments could not be made exactly natural, and it is probable that the adults of *E. mali* really live considerably longer than this in nature. Experiments along this line in 1907 indicate that they may live for thirty days or more.

Number of Broods.

The first brood began emerging in the insectary about May 21st. They may have begun to emerge even earlier than this, in small numbers, out of doors, as is shown by the sweepings on alfalfa. The earliest individuals of this brood had become adult in considerable numbers by June 4th. The first young of the second brood, collected on alfalfa, was found on June 21st. As no sweeping was done on the alfalfa between the 14th and 21st, it is quite possible that the first young really hatched several days before the 21st; though it is certain that, if they did do this, it was in very small numbers. Nymphs of this second brood were collected on July 9th, and the first adults were reared from them on July 17th. It is almost certain that the earliest of this second brood reached the adult condition several days earlier than this. If we take June 21st (the date on which the first nymphs of this brood were collected on the alfalfa) as the date of earliest appearance of the nymphs of this brood, and add twenty-two days (the average number of days passed in the nymphal stages, according to the 1907 and 1908 experiments and observations) to this date, we

have July 13th as the date on which the earliest of the second brood become adults. Adults of this second brood were reared and placed in pot lamp-chimney experiments, in order to get them to lay eggs for the third brood. They were placed on apple and box elder seedlings. These box elder seedlings had been gathered in May and kept in the insectary, and so had a good chance of not having had *Empoasca* eggs deposited in their tissues previous to the opening of these experiments. These adults were allowed to remain in each experiment for two days, and were then removed. In this way it was possible to figure out approximate length of time spent in the egg stage at the time of the season during which these experiments were conducted. The first of these experiments was opened on July 13th, and the first young which appeared in that way was found on July 31st. These experiments were continued until August 25th, and fully twenty nymphs of the third generation were hatched. The length of time spent in the egg stage by these nymphs ranged from about seven to about thirteen days, the average being about nine and one-half days. Adding twenty-two days (the average length of time spent in the nymphal stage) to July 31st, the time of the appearance of the first young of the third generation in these experiments, we get August 22d as the date on which the first of the third generation became adults. It seems likely (see above), judging from the probable time at which the first of the second brood became adults, that in reality the earliest of the third brood became adults several days earlier than August 22d, probably as early as August 18th at the latest. As winter egg-blister are not found until into September, it seems fair to assume that these earliest adults of the third brood do not deposit winter eggs, but lay eggs for a fourth summer generation instead. The further fact that living nymphs were found in all stages, on alfalfa, up to nearly the first of November, in the season of 1908, would also seem to indicate that there is at least a partial fourth brood of *E. mali* in Minnesota each year, though it must be remembered, of course, that development is much slower in the cool weather of September and October than during the summer months.

Summarizing, we may say that there are certainly three, and possibly four, broods of *E. mali* per season in Minnesota.

Economic Experiments.

Experiments with the hopperdozer for Empoasca on apple nursery stock:

A hopperdozer was constructed according to the plans given in the drawings which accompany this report, and was covered with canvas; the canvas being painted on the inside, in one trial, with crude oil, and in the other with tree tangle-foot; the idea being to drag the hopperdozer along the rows of small trees, the trees

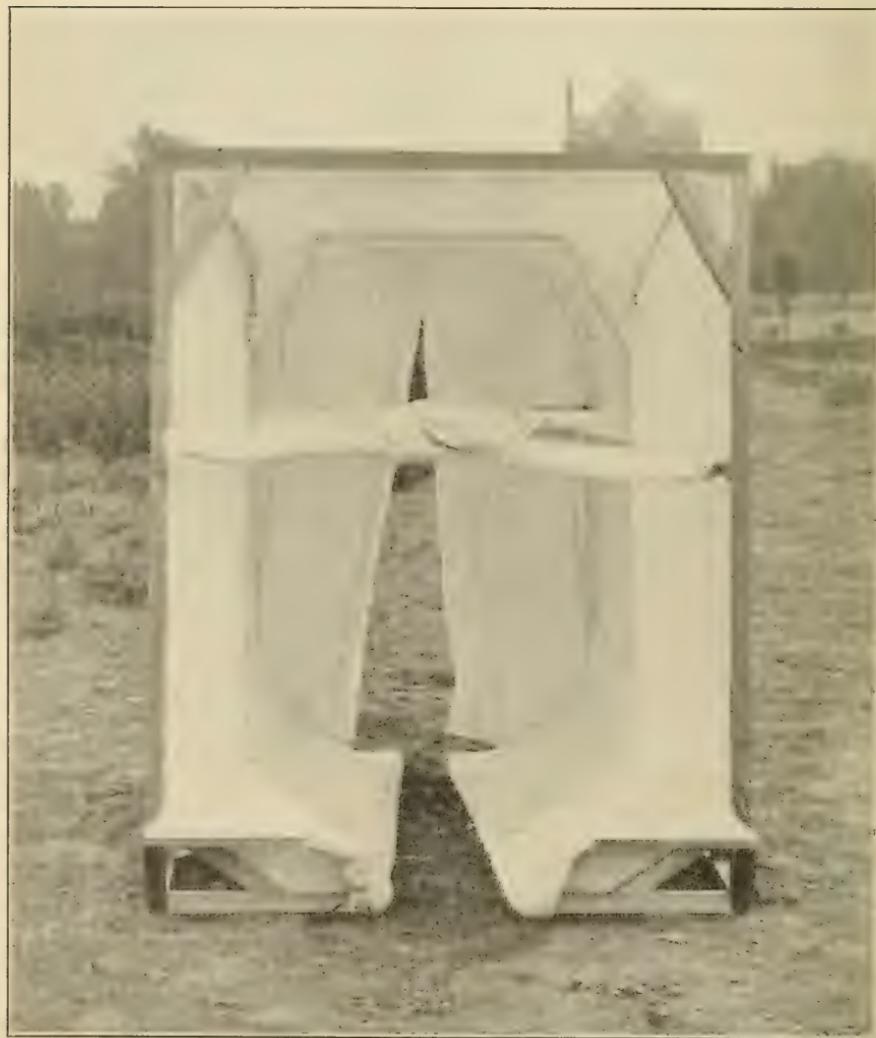


Fig. 17. Hopperdozer for use on nursery rows. Franklin.

passing through the hopperdozer and striking against a bumper at about its middle, and the adults of *E. mali* being shaken off from the trees, and flying in all directions, and naturally a great many of them lighting on the sticky oil or tanglefoot, and thus being caught and destroyed.

The experiments with the hopperdozer were carried out in the nursery of Mr. Wedge, at Albert Lea, on August 5th. The general idea and plan of the hopperdozer seemed to be good, but it was found to be too heavy for practical work on a large scale. It was found that the hopperdozer was much larger than necessary. As the average height of the young trees which are most affected is less than four feet, we found that the bumper was too high, as it would not touch the trees. We then lowered the bumper as low as it would go—within six inches of the bottom of the hopperdozer—and raised the handles so it would allow the hopperdozer to swing within six inches of the ground. In this way we were able to use it for the experiments. We found that the bumper was too far forward, as it would strike a tree and cause it to bend forward and strike other trees ahead, thus disturbing the leaf-hoppers before the hopperdozer got to the trees on which they were, and shaking them off in large numbers. We found that, by the trees being disturbed so soon, fully nine-tenths of the hoppers escaped from the interior portion of the hopperdozer without touching it. Practically all those which were caught were caught on the very front edges of the hopperdozer. We found that the crude oil was not effective, as the hoppers did not seem to cling to it very well; but the tree tanglefoot caught practically all that came in contact with it.

We found that the canvas curtains at the back of the machine, when they were covered with the crude oil, daubed the leaves of the nursery stock; and it is doubtful if these curtains are of any value, as the hoppers did not seem to fly backward at all.

The following counts were made on the apple stock in the rows after the hopperdozer had been run over the trees. Ten trees were taken for each count, and in all but the first two cases every third tree was taken.

1st row treated	10 trees, 7 young, 3 adults found on trees
2d row, next to treated row.....	10 trees, 59 young, 60 adults found on trees
3d row, treated	10 trees, 35 young, 12 adults found on trees
4th row, next to treated row.....	10 trees, 42 young, 14 adults found on trees
5th row, nine rows away from treat- ed rows	10 trees, 86 young, 42 adults found on trees

This would seem to show that, if the dozer had been so constructed that the hoppers could not escape from its anterior end, this treatment would have been very effective. At this time, September 22d, a new hopperdozer is being built and developed from our experience with the one which we used at Albert Lea, and from points gained by talking with practical nurserymen. This should be of service another season.

Suggestions for Further Work.

It does not appear that the feeding habits of this hopper have been discussed heretofore. In the next report the manner of their feeding on the under sides of the leaves, taking their nourishment from the under sides of the leaves, and leaving the upper surfaces with more nourishment, thereby causing them to grow more rapidly than the under sides, and thus curling the leaves downward, and the habit they have of always hiding on the under sides of any object on which they are placed, should all be discussed fully.

I have not seen a careful description of the different nymphal stages, though these have been figured if they have not been described. A careful and distinguishing description of each stage would be very desirable. A key to stages was made last summer.

The egg-laying capacity of each female should be worked out, if possible, and the proportion of the sexes at different seasons of the year be determined.

It would be desirable to give a brief discussion of this common pest, and a statement of how it may be found and recognized by farmers and others interested. Its predaceous enemies should be studied. If it has parasitic enemies, they are evidently very scarce, as we have discovered none in our numerous experiments of three seasons.

Consideration should be given to the possibility of spraying with either Bordeaux mixture alone, or Bordeaux mixture and resin, or fish oil soap, when the trees are in a dormant condition, or at least before time of hatching of the winter eggs, in order to cover the egg-blister with a covering which might prevent the hatching of the hoppers.

CONTINUATION OF WORK WITH CABBAGE MAGGOT IN 1909.

A large amount of work, representing many experiments, was carried on in 1909. Much of this work resulted negatively, but is deemed valuable in showing what is not effective, or what may be detrimental to the plants, although efficacious in keeping off the maggots. Much of this work is given here in detail.

Summarizing from results we can state that:

1. Tarred paper discs were found very effective. See p. 47.
2. Sawdust and glue were fairly efficacious, p. 49.
3. Treatment with carbolic acid emulsion, p. 54, gave excellent results. See also results with tobacco dust, p. 55.

On May 14th cauliflower plants were set out south of the insectary. On May 18th a row of these cauliflowers, containing 51 plants, was treated with O. & W. Thum Company's tree tanglefoot (brand R2). This was applied by first melting the tanglefoot in a tin pail, and applying it around the bases of the plants on the ground, when it had cooled to a temperature of 130 degrees Fah. It is probable that, before the application was finished, the temperature of the tanglefoot had got down as low as 110 degrees Fah. The tanglefoot was used at the rate of about one pound for 32 plants, and costs about 25 cents a pound, so that the material cost a little less than one cent a plant; which would make the cost of material for treatment of an acre extremely expensive. But the treatment was carried on with the hope that material might be obtained at less expense for this purpose if it was found to prove satisfactory.

On May 28th this row was examined, and it was found that 38 out of 51 plants used in the experiment, or about 75 per cent., had died on account of the treatment; but it was noticed that the plants stood the treatment all right in case the tanglefoot was not placed on the leading leaves. Of the 13 living plants 4 died later, so that on June 15th only 9 healthy plants were left. These were pulled up on June 15th, and all of them were almost entirely free from infestation, and only three were infested at all. The general results of the experiment may be said to be negative aside from showing that the tanglefoot will stop the maggots.

On May 19th cauliflowers, which had been planted below the Dairy Hall on May 14th, were also treated with O. & W. Thum Co.'s tree tanglefoot (Brand R2). The tanglefoot had to be

heated several times during the application and each time it was heated to about 140 degrees Fah. At times the temperature got down as low as 115 degrees Fah. during the process of application. In all there were 590 plants treated in this way, and 368 check plants were included in the experiment. The tanglefoot was heated in the following manner: The pails containing it were placed in a large kettle over a fire, and when melted up the tanglefoot was poured out into a pail and allowed to cool to a satisfactory temperature, and then applied with a spoon. In this crude way much more tanglefoot was necessarily applied to the bases of the plants than should have been required, and so the expense was much greater than it should have been. Furthermore, it was impossible to place the tanglefoot exactly in the position that was desirable, and so a great deal was daubed on the leading leaves, causing the death of the plants. It seems not altogether improbable that if a better means of applying the tanglefoot (perhaps by some double-boiler arrangement with a spout running out from it) could be devised, that this material could be applied in such a way as to make the treatment not very expensive, and so that it would not harm the plants seriously. Also such a method of application might save re-heating the tanglefoot several times, and so save time in application. Pains were taken to surround the bases of the plants entirely with the tanglefoot on all sides, and have it run out a full inch away from the bases of the plants on every side.

On May 28th the plants in this experiment were examined, and it was found that, out of the 590 treated plants, 360 had been killed, apparently by the tanglefoot treatment. The plants which had survived were retained and examined from time to time, for the purpose of seeing if the tanglefoot could stop the maggots, even if it could be made otherwise successful.

It must be remembered, in figuring up the proportion of the plants which died in the treated rows, that a considerable number of plants also perished in the check rows, so that probably many plants would have died even if the tanglefoot had not killed them. The check rows had lost, by May 28th, about 40 out of the 368 plants. The plants in this experiment were pulled up, a few on June 9th, a few on June 10th, and a few on June 19th, but most of them were pulled up on June 21st and 22d. When pulled, they were examined, and the infested and non-infested ones of each row of treated and check plants were both counted. The total results were as follows:

Treated, 75 entirely free, 48 infested.

Check, 20 entirely free, 113 infested.

This count, however, does not tell the whole story, as among the infested plants those which had been treated were much less infested, and much cleaner in appearance than were those which had been untreated and were infested.

On June 18th the experiment was tried of dipping the middle portions of cauliflower plants in melted tanglefoot, and then dropping them in water, and afterward setting them out in the field, it being thought that possibly this method would be the best means of applying the tanglefoot, as by this means very little tanglefoot would be used, and it could be kept entirely away from the leading leaves. It necessarily, however, got down nearer to the roots by this method of application. In addition in some cases cheap cotton batting was wrapped around the tanglefoot on these plants, as it was thought the cotton might prove an added barrier to the maggots, and at the same time make the operation of setting out less objectionable.

In these tests practically all of the treated plants died, while most of the check plants survived; and, in the case of the treated plants which survived, there was not much evidence in favor of the use of this treatment against the maggots.

Experiments with Soot.

Cauliflower plants set out May 14th were treated on May 18th, by placing a trowelful of dry soot around the bases of the plants. This covered the ground about the stem for a radius of about five inches. As the soot had become more or less blown away by the wind, and mixed with dirt by rains, another application similar to the first was made on the 28th; and, as this had become badly mixed with dirt by June 2d, a lot of soot was mixed up with water, and the soot dough was applied around the bases of these plants. Twenty-seven of the plants in this experiment were pulled up and examined on June 10th, and 16 were pulled up and examined on June 15th. Out of the total of 43 plants, 38 were found to be more or less infested by maggots, which shows that this treatment was not at all effective. Further than this, it was found that the plants in this row were badly troubled by cutworms; much worse than were other rows of cauliflowers treated differently. The cutworms seemed to like to work into the soot, and they were found imbedded in the soot in a large number of instances. At least one

cutworm was taken away from every plant in this row, except one or two, and in some cases as many as four were taken away from a single plant. It is probable that they took to the soot in this way on account of its black color, which caused it to absorb a great deal of heat during the day and retain it during the night.

On June 3d a row of 81 cauliflower plants were set out, and on June 4th every other plant in the row was treated with a batch of soot dough placed around its base. The soot covered the ground for a distance of six inches away from the plants on every side. On June 22nd 27 of the plants were pulled up and examined, and on July 20th 34 others were examined. Of the treated plants, 17 were found to be infested and 14 free from infestation, and of the check plants 12 were found to be infested and 18 free; so the general results of the treatment with soot were negative.

Experiments with Lime.

A row of cabbages, planted on May 14th, had the alternate plants treated on May 18th with air-slaked lime, about a trowelful of the lime being used around the base of each plant. This covered the ground around the stem of the cabbage for a radius of four inches. The lime having become somewhat mixed with soil by rains, this treatment was repeated on May 28th. On June 17th 19 plants were pulled up and examined, and on August 20th the remaining 24 were pulled up and examined. The results were entirely negative, as many of the treated plants, as of checks, being found infested.

Experiments with Carbolic Acid and Lime.

Cauliflowers planted May 18th, belonging to Mr. Fisher, of St. Anthony Park, were treated on May 20th with carbolic acid and lime; the formula given in the New Jersey Bulletin No. 200 being followed. These plants were treated again in the same way on June 1st, a third time on June 16th, and the fourth time on June 26th. These plants were cultivated twice, the first time on the 28th of May, and the second on the 8th of June. On July 12th some of the plants had reached maturity, and Mr. Fisher began harvesting them. On July 14th the roots of the cut plants were pulled and examined, and afterward the remaining roots were cut and examined every few days as the harvesting proceeded; examinations and counts being made on the following days: July 16th, July 23d, and August 3d. After the last counting the results

were added up, and we found that of the treated plants there had been 48 marked by the maggots, and six not marked, and of the checks 113 marked, and 13 free; two rows, one on either side of the treated row, having been used as checks. From this standpoint, nothing is shown in favor of the treatment. A few plants were left after the last count, but these were not examined, as the second brood of maggots was now coming on, and any treatment would by this time have fulfilled its purpose on the first brood.

On July 16th, after a portion of the plants in this field had been harvested, we counted the number of heads that were tied up, and also all that promised the development of marketable heads, in both the check rows and the treated rows, with results as follows:

Check on one side...	44 tied, 20 to be tied.
Treated	58 tied, 21 to be tied.
Check other side....	61 tied, 15 to be tied.

This shows but little, if anything, in favor of the treatment.

Experiments with Tarred Felt Discs.

Cauliflowers planted May 14th were treated with tarred felt discs, 825 plants having discs applied. These plants also belonged to Mr. Fisher, of St. Anthony Park. These treated plants were in three rows, and check rows were left between and on both sides of them, so that the check and treated rows alternated. The discs were bought already cut, and they cost \$2 for the 825. It took three men an hour to apply them to the plants.

On May 28th these plants were examined, and the discs were found badly covered up with dirt on account of the cultivation. The dirt was brushed off of the discs on this date. These plants were cultivated on May 28th and again on June 7th. The cultivation threw the soil over the rows in such a manner as to cover up the discs to a depth of a couple of inches or more. On June 15th the soil was again removed from the discs. As Mr. Fisher began to harvest these plants on July 12th, and had thrown out the roots where they had dried up, we were unable to begin making counts until July 14th. The roots of plants which were small and did not make heads were pulled up and examined, as well as the cut-off roots which were left in the ground by Mr. Fisher. Plants were pulled up and examined on July 14th, 16th, 20th, 23d and August 3d. The plants had, as usual, a very marked difference in favor of the treatment, and a difference was noted throughout the count-

ing, but it became less and less noticeable toward the last, as the second brood of maggots was beginning its work, and the discs had by this time become so covered up and out of shape that they were of little value. This will be shown best by the following counts. The count made on July 14th was as follows:

Treated	92 infested,	56 free.
Check	172 infested,	15 free.

AUGUST 3d.

Treated	19 infested,	1 free.
Check	23 infested,	0 free

Totalling the counts made on the dates above mentioned, we found of the treated plants 241 infested, 99 free; and of the checks, 346 infested, 37 free. It should be noted here, also, that the marked roots in the treated rows were, as a rule, much less badly marked than were those in the check rows. It will be noted that the total number of counted plants does not equal anywhere near the number of plants first regarded as being included in the experiment. This was due to the fact that Mr. Fisher had already harvested part of the crop when we began counting, and that we left a part of the plants uncounted because it did not seem worth while to continue the count further.

On July 16th we also counted the plants which were marketable, and were likely to become so, which remained in the treated and check rows at this date, part of the harvesting having been done. The plants, the heads of which were tied up, were counted, and the plants which had begun to develop heads and were large and thrifty were also counted separately. The results of these counts were as follows, the rows being given in the order of their position, T denoting the treated rows, and C denoting the check rows:

	Heads not tied up,	
	Heads tied up.	but of good size.
C	62	21
T	82	27
C	63	20
T	50	21
C	42	5
T	60	13
C	41	5

This gives a total count as follows: (T) treated 129 tied, 61 not tied, but in good condition—three rows. Check (C) 213 tied, 51 not tied—four rows. Reducing these figures to a comparative basis, we would have on the basis of three check rows instead of four, at the same rate of infestation as was found to be present in the four, 160 tied plants and 38 headed but not tied, to be compared with 192 tied and 61 headed in the three treated rows. This gives a balance of 32 tied and 23 headed but not tied in favor of the treated plants in three rows, or a total of 55 heads saved in the treated rows, that is 55 heads saved by treating 825 plants. As there are usually about 7,000 cauliflower plants to the acre, this would mean a saving of about 467 heads an acre by this treatment. But it must be remembered that this was not a fair test, as the treatment was applied a considerable time after the plants were set out, and the discs were allowed to get badly covered up with earth for a considerable length of time. The regularity with which the treatment improved the rows to which it was applied is interesting and noticeable. Compare the results of the counts above given, the number of heads in each of the check rows, with the treated row or rows next to it. This treatment must be considered by far the most satisfactory of all those tried during the season, everything considered.

Experiments with Sawdust and Glue.

Cauliflowers planted on May 14th, belonging to Mr. Fisher, of St. Anthony Park. On May 22d 173 plants in this experiment were treated with a preparation made as follows: Four pecks of sawdust, 4 pounds of slaked lime, 4 pounds of hard glue, 4 gallons of water. The lime was mixed dry with the dry sawdust; the glue was dissolved in the water, which was first brought to the boiling point, and then the glue and water were added to the lime and sawdust and thoroughly stirred up. A handful of this preparation was placed around each plant, covering the surface of the ground about the stem of the plant for a radius of about three inches. The rows on either side of the treated row were used as checks. Two men applied this treatment to the 173 plants in about thirty minutes. The glue cost about 25 cents per pound, making the cost of the treatment about \$1.25 for the 173 plants, which must be considered very expensive.

On June 15th a few of these plants were pulled up, and one out of every three were found to be badly infested. The plants were

cultivated on the 28th of May and on the 7th of June. Mr. Fisher began harvesting the cauliflowers in this patch on July 12th. We pulled up, examined and counted the roots of the plants from which the heads were cut from day to day, on the following dates: July 14th, 16th, 23d and August 3d; and, summing up the results of all these examinations and counts, we found of the treated plants 42 infested, and 6 free. This shows nothing in favor of the treatment. On July 14th the heads which were tied up and the plants which were large and in good condition and promised to become marketable, were all counted with results as follows:

Check on one side..	66 tied, 18 to be tied.
Treated row	20 tied, 5 to be tied.
Check on other side	21 tied, 6 to be tied.

The check row which had the largest number of good plants was twice as long as either the other check row or the treated row, so here again nothing is shown in favor of the treatment. The second check row was on the very margin of the field, and the plants could hardly be expected to be as thrifty there as in the other rows, in any case.

On June 12th three rows of young cauliflower plants were set out and treated with a sawdust-and-glue preparation, made up according to the formula in the New Jersey Bulletin No. 200. Alternate plants were treated, and the intermediate ones were left as checks. One row contained 67 plants, the second contained 65, and the third 47. On August 25th these plants were all pulled up and their roots examined, as follows:

Treated	21 free, 10 marked.
Checks	14 free, 37 marked.

This gives some evidence in favor of the treatment. Many check and treated plants died because of lack of moisture.

On June 15th two rows of cauliflowers were set out on the Station grounds, and treated at once with sawdust and glue, the following formula being used in the preparation of the mixture: Four pounds hard glue, 2 gallons water, 2 pecks sawdust. There were 63 plants in one row, and 59 in the other. Every other plant in both rows was treated, the alternating plants being used as checks. On August 25th the plants in this experiment were pulled, and their roots examined, with results as follows:

Treated	10 free, 18 marked.
Checks	2 free, 35 marked.

This gives considerable evidence in favor of the treatment. Many plants died on account of lack of moisture. The loss of plants was divided about equally between the treated and untreated plants.

Miscellaneous Treatments.

On May 31st four rows of cauliflower plants were set out on the Station ground, one row being used as a check, the others being treated on June 2d, as follows:

One row of 64 plants Dr. Franklin treated with air-slaked lime placed around the base of the plant about three inches in every direction; one row of 77 plants he treated with cotton batting wrapped around the base of the plant after it was set out, and being pushed down somewhat into the dirt and held down by the dirt being pressed around it. The cotton stood up from an inch to an inch and a half from the dirt, all the way around the plant. It took 8 cents worth of cotton to treat 101 plants. Another row of 57 plants was treated with cotton batting in a similar way, and one row of 59 plants was treated with cotton batting and creosoted sawdust. The cotton was applied as in the case of the other two rows, and the creosoted sawdust was placed around the cotton, but not allowed to come in contact with the plant tissue. On June 3d these rows were examined, but it was found that nearly all the plants treated with cotton batting and creosoted sawdust were dead, evidently on account of the creosoted sawdust. These plants were removed and fresh plants were put in their places, and these were treated with cotton batting as soon as set out, in a manner similar to the other two rows treated with cotton. On June 15th the row treated with lime was treated again. On August 9th the row treated with lime was pulled up, and the roots of all the plants examined with results as follows: Seventeen marked by maggots and four not marked. The check row was likewise examined on this date, with the following results: Thirteen marked and thirteen free from marks. This gives no evidence in favor of the lime treatment.

The plants in the three rows treated with cotton batting were also examined at this time, and there was no evidence shown in any of the rows in favor of the treatment. It should be noted here, however, that the cotton batting treatment in these experiments did not really have a fair chance to prove its value; as English sparrows from the first were a great nuisance in tearing away the

cotton and carrying it away for nest-building, and it had to be continually replaced, until finally tobacco was dusted on the cotton, after which the birds left it alone fairly well. This trial of cotton was hardly made with the expectation of its being practical for market gardeners, but in order to see whether or not it would act as a barrier in preventing the fly getting close enough to the plant to lay her eggs thereon. If it did we thought that some modification of this method, of real utility gardeners, might be denoted.

One row of 27 cauliflower plants was set out, partly on May 14th and partly on May 29th. It was treated with waxed paper and creosoted sawdust on June 2d. The paper was put around next to the plants, and the sawdust around that. The treatment injured the plants badly.

Another row of 42 plants, set out on May 29th, was treated similarly on June 2d, and on June 3d all plants were dead. Evidently creosoted sawdust cannot be used in any way for the cabbage maggot.

A row of 88 cauliflower plants was set out on June 3d, below the Dairy Hall. On the morning of June 4th every other plant in this row was treated with cotton, the cotton being wound around the stem of the plants and at the bottom pushed down in three or four places: the dirt being closed up to hold the cotton firmly down.

On the morning of June 7th these plants were examined, and it was found that the cotton had been torn away by the sparrows for nest-building. This occurred several times, and the damage had to be repaired, and finally tobacco was used for keeping the birds away. On June 22d the plants in this experiment were pulled up, and the roots examined, with results as follows:

Treated plants 9 marked, 15 free.

Check plants 18 marked, 13 entirely free from infestation,
—showing some advantage for the treatment.

A row of 80 cauliflower plants, set out on June 3d, was also treated with cotton, as described in the experiment just discussed. This experiment was also bothered by the birds. These plants were also pulled up on June 22d and examined, with results as follows:

Treated 10 marked, 25 free.

Checks 17 marked, 17 free.

—this, too, showing some advantage in favor of the treatment.

Cauliflower plants, set out on June 9th, had cotton wrapped around them when they were set out, so that the cotton was stuck down into the dirt about an inch, and above the soil about three-fourths of an inch. There were two rows treated in this way, the alternating plants being treated, on this date. In one row there were 76 plants, and in the other 88 plants. On August 25th the plants remaining in these rows were pulled up, and their roots examined. Out of the 164 plants, of the treated plants, only 22 were living. The death of the plants is not to be attributed to the treatment, because as many check plants as treated ones died, but to the fact that either the plants were in poor condition, or that they were not set out properly. Of the treated plants 3 were found to be free from infestation, and 8 had been marked by maggots. Of the check plants 5 were free from infestation and 6 had been marked by maggots. This gives no evidence in favor of the treatment.

On June 12th and 17th two rows of cauliflowers were set out with cotton wrapped around them, the cotton being stuck down into the dirt about an inch, and above the soil about three-quarters of an inch, as above described. These two rows contained in all 123 plants, alternating plants being treated in both rows. In the case of these two rows also there was no evidence to be found, when the plants were pulled up and examined, in favor of the treatment. On the whole it must be said that the cotton treatment was entirely unsatisfactory.

Treatment with Sulphur.

Two rows containing between them 185 plants were set out on June 4th on the Station grounds, and were treated with sulphur about the bases of their stems on the morning of June 6th. The alternating plants in these rows were treated, the remaining plants being left as checks. About half a trowelful of sulphur was used for each treated plant. The sulphur remained in good condition, unmixed with soil, as long as this experiment continued. It took 14 pounds of sulphur for 81 plants, making this treatment rather expensive. On July 12th the plants in these rows were pulled up and examined with results as follows:

Treated	11 marked, 42 free.
Check	6 marked, 29 free.

It will be noticed that many of the plants had died, apparently through poor condition, or on account of being improperly set, rather than on account of the treatment. This experiment showed no evidence in favor of the treatment.

Miscellaneous.

On June 9th a row of cauliflowers containing 86 plants was set out on the Station grounds, the alternating plants being wrapped in waxed papers about their middle portions, their roots extending below the paper, and the tops of the plants projecting above it. The paper protruded about an inch above the ground, and was wrapped tightly about the stalks, it having been folded before it was wrapped, so that there were three or four thicknesses of the paper between the soil and the stalks of the plants. On August 25th the plants were pulled up and the roots examined and counted with results as follows:

Treated	6 marked, 1 uninfested.
Checks	7 marked, 1 uninfested.

This gives no evidence in favor of the treatment. It will be observed that the majority of the checks and treated plants died for some reason aside from the treatment.

On June 15th a row of cauliflowers containing 34 plants was set out, and all plants treated at once with hellebore decoction (see formula given in the Twelfth Report of the Minnesota State Entomologist, Page 136). On June 22d these plants were treated again as before, and also again on July 20th; the long space of time between June 22d and July 20th having been allowed to pass without treatment, because the maggots were at this time passing apparently into the pupal or adult stages, and were not active. On August 26th the plants were pulled up, and the roots examined with the following results:

Treated	13 free, 31 marked.
Checks	2 free, 35 marked.

(In another row, when set out of equal number.)

This shows some evidence in favor of the treatment.

Carbolic Acid Emulsion.

A row of cauliflowers containing 58 plants, set out on June 15th, was treated *as soon as set out* with carbolic acid emulsion, made according to the formula given in Smith's New Jersey Bulletin No. 200. On June 22d this emulsion was applied again, and on July 20th the plants were treated a third time. In this experiment as in the one just described, there was no treatment applied between June 22d and July 20th, because the maggots were not active. On August 26th the plants were pulled up and the roots examined, with results as follows:

Treated, 21 free from infestation, 13 marked by maggots.

Checks, in another row, 2 free, 35 marked.

Another check row, with an equal number of plants when set out, gave a count of 7 free, and 31 marked, which shows considerable evidence in favor of this treatment with carbolic acid emulsion.

Tobacco Dust.

On June 22d a row containing 37 plants of cauliflowers was set out. All the plants in this row were treated with tobacco dust, sifted around the stems as soon as set out, and again in a similar way on July 13th. On August 26th these plants were pulled up and examined, with results as follows:

Treated 14 free from infestation, 2 marked.

A check row containing same number of plants gave a count of 7 free, and 31 marked, showing much evidence in favor of the treatment.

EXPERIMENTS WITH THE CABBAGE MAGGOT ON RADISHES, 1909.

The following experiments with the cabbage maggot on radishes indicate that hellebore decoction is useful as a deterrent. (See p. 55). Also carbolic acid emulsion, p. 56; and not only that the tobacco dust treatment is a good preventive, but that tobacco is a fine fertilizer for radishes, p. 57. Air-slaked lime injures radishes if applied liberally, see p. 57.

Radishes were planted on May 31st, in plots on the Station grounds as follows: Plot 1 contained 16 rows; plots 2 and 3 contained 14 rows each; plots 4 and 5 contained 15 rows each. Each row was 12 feet in length. Plot 4 was reserved as a check on the others. When the radishes began to show above ground, on June 3d, those in Plot 1 were treated, on June 8th, with hellebore decoction (see Twelfth Report of the Minnesota State Entomologist, Page 136, for the formula); the radishes at this time being one and a half inches high. Hellebore decoction was applied with a sprinkling can, without the rose, along the rows. The ground around the radishes was thoroughly moistened with the decoction. This plot was treated again on June 15th, a third time on June 19th, a fourth time on June 24th, and a fifth time on July 3d, after some of the radishes had been pulled and counted.

Plot 2 was treated with carbolic acid and lime on June 8th, the same date that Plot 1 was treated. The formula given in New Jersey Bulletin No. 200 was followed. This treatment was applied several times more on the following dates: June 15th, June 19th, June 25th, July 3d, July 23d; the last two applications being made after a part of the radishes had been pulled and examined.

Plot 3 was treated with sulphur on June 4th. The tallest of the plants were at this time between 1 and $1\frac{1}{2}$ inches high. The sulphur was sprinkled very thickly along the rows, so as to completely surround the bases of all the plants. It took $45\frac{3}{4}$ pounds of sulphur to treat this plot. Of course, the expense of such treatment would be out of the question for radishes, but it was hoped by this application evidence might be obtained as to the value of sulphur as a preventive of cabbage-maggot attacks on cauliflowers, where a smaller amount of sulphur would be required for the returns expected.

Plot 5, on June 8th, was treated with an emulsion of carbolic acid and ivory soap. This, it will be noticed, was the date of the first treatment of plots 1 and 2. The carbolic acid emulsion was made up according to the formula given in N. J. Bulletin 200. This plot was treated again on June 12th, a third time on June 19th, a fourth time on June 24th, again on July 3d and July 23d—the last two times after the first radishes had been pulled and examined. The roots were pulled and examined in these plots as we got time for the work, as nearly as possible when they were large enough for table use in numbers, the dates being June 30th, July 17th and August 2d. The sum total of the counts made on these dates was as follows:

Plot 1	219 marked, 686 entirely free.
Plot 2	138 marked, 1,132 entirely free.
Plot 3	557 marked, 597 entirely free.
Plot 4	75 marked, 842 entirely free.
Plot 5	101 marked, 1,122 entirely free.

It will be seen that these results are somewhat questionable as far as the maggot is concerned, (see check row No. 4) due, possibly, to the fact that the maggots were not very active during the period when the radishes were in the ground.

Four plots of radishes, planted on June 4th, each containing 10 rows 9 feet long, were all contiguous with one another; plots 1 and 3 being check plots, and 2 and 4 being treated plots.

Plots 2 and 4 were treated on June 10th, when all the plants were about three-fourths of an inch high, with tobacco sifted along the rows in considerable quantity, so as to surround the stems of all the plants. It took eight pounds of the tobacco-dust to treat each of these plots in this way. On June 13th these two plots were again treated. On July 20th the radishes, which were of table size, were pulled, their roots examined and counted. Since the last treatment the maggots had apparently not been active. The untreated check plots were also pulled and the roots examined and counted on the same date:

Plot 1	755 entirely free, 489 marked by maggots.
Plot 2	952 entirely free, 299 marked by maggots.
Plot 3	1,022 entirely free, 200 marked by maggots.
Plot 4	1,269 entirely free, 119 marked by maggots.

This gives considerable evidence in favor of the tobacco treatment.

Two plots of radishes were planted on June 4th. Plot 1 contained 14 rows, each $10\frac{1}{2}$ feet long, and plot 2, 15 rows, each $10\frac{1}{2}$ feet long. Plot 2 was used as a check, and plot 1 was treated on June 8th with a uniform coating of air-slaked lime. It was again similarly treated on June 15th. It was found that the treatment was not going to give any particular results as regards keeping off the maggots, particularly because the maggots were not very active at that time. On July 19th radishes in both plots were pulled up, and those of table size were counted. This was to find out what effect the lime had on the growth of the radishes. The general appearance of the plots seemed to plainly indicate that the lime was detrimental to the radishes. It was found that plot 1 (the treated plot) contained 2,561 radishes of table size, and practically no small radishes were left after these were pulled and counted, while plot 2 (the check plot) contained 2,814 radishes of table size, and many radishes were still left which were too small for the table, the count proving conclusively that the lime was detrimental.

Plots of radishes were also treated with lime and oil of cloves, and with carbolic acid emulsion, and in every case the treatment was more or less, and in some cases, severely injurious. The radishes in all the plots of this season's experiments were Early Scarlet Globe.

On June 23d a radish plot was planted, containing eight rows, each $10\frac{1}{2}$ feet long. On July 14th the odd, or alternating rows in this plot were treated with tobacco-dust, the other rows being left as checks. On August 12th all the radishes of table size in this plot were pulled and their roots examined, with the following total results: 521 roots from the odd or treated rows; 309 roots from the even or check rows—this showing the fertilizing value of the tobacco radishes. In the case of the treated radishes, there were 102 showing marks of maggots, and 419 without such marks, while of the check plants there were 51 showing maggot marks, and 258 which did not, which shows no advantage, from the maggot standpoint, in the treatment.

**MINNESOTA NURSERY INSPECTION:
INSPECTION OF IMPORTED EUROPEAN STOCK.**

1909 and 1910.

Our inspection of state nurseries appears to be on a satisfactory basis, at least for the time being. The state law, it is true, is somewhat lax; but, at a conference of some of our leading nurserymen and the entomologist, it was not thought advisable to attempt any change in 1911, in view of the possibility of a federal law in the near future. Letters from nurserymen not in attendance at this conference expressed practically the same views as those given at the meeting, namely, satisfaction with the present law and the way it was administered; with a feeling that no change should be made until something decidedly better should be offered in its place.

In 1909 nurseries looked vigorous and thrifty. The growth of apples, shrubs and canes was generally very striking, the best for years. There was plenty of apple aphid, though damage from this insect was slight. The apple leaf-hopper was also abundant; but the trees were making such a vigorous growth, before the hoppers put in an appearance, that growth was not materially checked. Other insects in evidence were the Poplar and Willow Beetle, *Melasoma scripta*, doing much damage in some of the Southern nurseries to young poplars, but easily kept in check by proper spraying with arsenate of lead; the Plum Curculio and Codling Moth in orchards; the Eight-spotted Forester, the Leaf-roller of the Basswood, *Pantographa limata*, the Fall Web Worm, the Oyster-shell Scale, and various leaf-eating caterpillars.

Mr. Ruggles, who did the inspection in 1909, also reported the following diseases in orchards and nurseries: Crown Gall on raspberries, Anthracnose on raspberries, Leaf Blight on box elder, Pear Blight (Fire Blight), Scab.

The crown gall on raspberries was very abundant. He reported it as being more abundant where plants had been disturbed than in beds not so disturbed, and advances the theory (which is perfectly possible) that the cutting away of the young plants, leaves wounds

where the bacteria, if present in the soil, may enter. Anthracnose was found in one nursery. Blight on box elder was not bad, noted in only one nursery. The same was true of fire blight. Scab was quite noticeable wherever proper spraying had not been practiced. We append a list of the nurseries inspected in 1909:

		Cert. No.
June 24	Faribault Nursery, O. F. Brand & Son, Faribault....	\$3.00 273
" 24	Farmers' Seed Co., Faribault.....	3.00 274
" 24	Andrews' Nursery, Faribault	3.00 275
July 15	Howard Lake & Victor Nurseries, Howard Lake....	4.50 276
" 22	Jewell Nursery, Lake City.....	4.50 277
" 22	Tolleson Nursery, Lake City.....	3.00 278
" 22	Johnson Nursery, Lake City.....	3.00 279
" 26	Fred Cowles, West Concord	2.90 280
" 26	W. E. Fryer, Mantorville	2.90 281
" 26	F. E. Cutting, Byron	2.90 282
" 27	C. H. Ritter Berry Farm, Plainview.....	4.50 283
" 15	North Star Plant Farms, Cokato.....	3.25 284
" 15	Wright County Nursery, Cokato.....	3.25 285
Aug. 4	B. T. Hoyt, St. Paul.....	1.25 286
" 5	John Hawkins, Rose Hill Nursery, Minneapolis.....	1.50 287
" 7	Vine Grove Nursery, Minneapolis.....	2.60 288
" 7	J. W. Strand, Taylors Falls.....	4.56 289
" 9	A. O. Hawkins, Deep Haven Nursery, Wayzata.....	1.50 290
" 9	Chas. Hawkinson, Wayzata	1.50 291
" 10	W. A. Yahnke, Pleasant Valley Fruit Farm, Winona	4.75 292
" 11	Wm. Sandrock, R. R. No. 3, Rushford.....	4.75 293
" 12	C. E. Snyder, Preston	4.75 294
" 12	G. A. B. Howell, Spring Valley.....	4.75 295
" 13	J. M. Lindsay, Austin	4.25 296
" 13	C. F. Woodle, Austin	4.25 297
" 13	P. J. Regan, Twin City Nursery, Hopkins.....	2.50 298
" 14	L. L. May & Co., St. Paul.....	5.72 299
Aug. 16	L. D. Mills, Mills Lake Nursery, Lake Crystal.....	\$4.85 300
" 16	L. Z. Smith, Mankato	4.85 301
" 17	Norway Poplar Nursery, Emil Sahler, Waseca.....	6.35 302
" 17	Wm. Pfaender, Jr., New Ulm	4.85 303
" 20	B. P. Christensen, Hutchinson	4.56 304
" 20	Holm & Olson, St. Paul	2.25 305
" 20	Wedge Nursery, Albert Lea	3.00 306
" 20	Albert Lea Nursery, Albert Lea.....	2.00 307
" 20	Minnesota State Nursery, Albert Lea.....	2.00 308
" 20	Clinton Falls Nursery, Owatonna	4.25 309
" 20	Mitchell Nursery, Owatonna	3.25 310
" 20	Mayfield Nurseries, L. L. May & Co..... 311
" 23	S. D. Richardson & Son, Winnebago	4.00 312
" 23	P. C. Christensen, Fairmont	4.00 313
" 24	G. D. McKisson, Fairmont	4.00 314

		Cert. No.
" 24	B. E. St. John, Fairmont	4.00 315
" 24	E. J. Lewis, Jackson	4.50 316
" 24	L. Meininger, Sherburne	4.50 317
" 25	Kanaranzi Nurseries, Adrian	4.50 318
" 25	C. E. Older, Luverne	4.50 319
" 25	F. A. Ward, Pipestone	4.50 320
" 26	Lyon County Evergreen Nursery, Cottonwood.....	6.00 321
" 27	C. J. Orton, Marietta	6.00 322
" 28	E. Soholt, Madison	6.00 323
" 30	A. Wilwerding, Freeport	8.00 324
" 31	A. W. Patten, Mora	8.00 325
Sept. 3	C. H. Brady, Deerfield	4.50 326
" 14	Northwestern Nursery, Lake City.....	7.90 327
" 15	Brackett Nursery, Excelsior	1.15 328
" 15	A. A. Bost, Excelsior	1.15 329
" 15	Old Fashioned Flower Garden, Excelsior.....	1.15 330
" 15	Lyman's Nursery, Excelsior	1.15 331
" 15	Hennepin County Nursery, Eden Prairie	3.00 332
" 15	J. A. Flagstad & Sons, Sacred Heart.....	6.25 333
" 15	Elliott & Redpath Nursery, Crystal Bay.....	1.00 334

\$234.74

This amount (\$234.74) was deposited with the State Treasurer.

In 1910 we deputized Mr. F. J. Crider, a graduate of the Agricultural College and specialist in Horticulture and Entomology, to do the inspection. He was instructed to make careful examination for crown gall on raspberry, and to notify the nurserymen that where over ten per cent of plants were found infested a certificate would be denied until satisfactory assurance was given the inspector that said plants had been destroyed. We were obliged to refuse a certificate to a few of the growers until that had been done. He found, in addition to crown gall, some woolly aphid, an abundance of Buffalo tree-hoppers, and various plant-lice, twig-borers on box elders, the Striped Poplar Beetle, Oyster-shell Scale, Apple Leaf-hopper, Willow Scale, Lecanium Scales, and other insects of minor importance. Inspection of nurseries in 1910 occupied the time from June 8th to July 30th.

**NURSERIES INSPECTED AND CERTIFICATES GRANTED
IN SEASON OF 1910.**

		Cert. No.
May	6 Peter Sivert, Canby	\$17.50 335
June	6 Northwestern Nursery, Lake City.....	2.60 336
"	8 B. T. Hoyt, St. Paul.....	2.00 337
"	8 Rose Hill Nursery, Minneapolis.....	2.50 338
"	10 Vine Grove Nursery, Minneapolis.....	2.60 339
"	10 Holm & Olson, St. Paul	2.60 340
"	11 L. L. May & Co., St. Paul.....	5.80 341
"	13 Strand's Nursery, Taylors Falls	5.00 342
"	13 Chisago Lake Nursery, Lindstrom.....	5.00 343
"	14 Deephaven Nursery, Wayzata	2.50 344
"	14 Chas. Hawkinson, Wayzata	2.50 345
"	15 Hennepin Co. Nursery, Eden Prairie.....	3.00 346
"	15 Old Fashioned Flower Garden, Excelsior.....	1.30 347
"	15 Bracketts Nursery, Excelsior	1.30 348
"	16 Elliot & Metcalf, Crystal Bay.....	2.50 349
"	17 Howard Lake & Victor Nurseries.....	5.50 350
"	17 Wright Co. Nursery, Cokato	4.50 351
"	20 A. Wilwerding, Freeport	8.00 352
"	21 Oslund's Nursery, Cambridge	8.00 353
"	22 B. P. Christensen, Hutchinson	5.00 354
"	23 J. Flagstad & Son, Sacred Heart.....	6.50 355
"	24 M. Soholt, Madison	6.00 356
"	24 C. J. Orton, Marietta	6.00 357
July	1 C. E. Older, Luverne	6.00 358
"	2 Kanaranzi Nurseries, Adrian	6.00 359
"	5 E. J. Lewis, Jackson	5.00 360
"	5 P. C. Christensen, Fairmont	4.50 361
"	5 G. D. McKisson, Fairmont	4.60 362
"	6 B. E. St. John, Fairmont.....	4.55 363
"	6 S. D. Richardson & Son, Winnebago.....	5.00 364
"	7 Wedge Nursery, Albert Lea	3.50 365
"	7 Albert Lea Nursery, Albert Lea.....	2.00 366
"	7 Minnesota State Nursery, Albert Lea.....	2.00 367
"	8 J. M. Lindsay, Austin	5.00 368
"	12 G. A. B. Howell, Spring Valley.....	4.75 369
"	12 C. E. Snyder, Preston	4.75 370
"	13 Wm. Sandrock, Rushford	5.75 371
"	15 W. A. Yahnke, Winona	4.75 372
"	15 Tolleson Nursery, Lake City	4.00 373
"	15 Johnson Nursery, Lake City	3.00 374
"	15 National Nursery Co., Lake City.....	5.00 375
"	17 Mrs. Nils Anderson, Lake City.....	4.00 376
"	17 Jewell Nursery, Lake City	7.50 377
"	20 C. P. Nichols, Northfield	6.50 378
"	21 J. P. Andrews, Faribault	4.00 379
"	21 O. F. Brand & Son, Faribault	5.00 380

		Cert. No.
" 21	Farmers Seed Co., Faribault.....	6.00
" 22	L. Z. Smith, Mankato	3.00
" 22	Wm. Pfaender, New Ulm	4.00
" 25	Emil Sahler, Waseca	4.00
" 25	D. M. Mitchell, Owatonna	4.00
" 26	Clinton Falls Nursery, Owatonna.....	6.00
" 27	C. H. Brady, Medford	4.50
" 28	W. E. Fryer, Mantorville.....	3.00
" 28	F. E. Cutting, Byron	3.50
" 29	C. H. Ritter, Plainview	4.00
" 30	Fred Cowles, West Concord.....	3.50
Aug. 30	J. V. Bailey, Newport.....	2.88
		\$263.73

This amount (\$263.73) was deposited with the State Treasurer and receipt received for the same.

The following nurseries do not receive inspection (1910):

Anderson, Adolph, Renville.	Mora Nursery, Mora.
Baker, Chas. E., Albert Lea.	Norden Nursery, Albert Lea.
Beckman, J. W., Cokato.	John Osborn, Dassel.
Campion, J. A., Faribault.	Parker, W. L., Farmington.
Chapman, R. W., Plainview.	Perry, P. M., Excelsior.
Doolittle, C. J., Lake City.	Perry, Frank, Stillwater.
Gopher State Nursery, Albert Lea.	Twin City Nursery, Hopkins.
Harrison, H. W., Le Roy.	Rochester Fruit & Plant Nursery, Rochester.
Haseltine, F. T., Crookston.	St. James Nursery, St. James.
Keays, A. W., Elk River.	Stephens, J. M., Crookston.
Lyman, A. B., Excelsior.	Tanner & Seager, Cannon Falls.
Lyon County Evergreen Nursery, Cottonwood.	Taylor, G. D., Fulda.
McMullen, Anthony, Madelia.	Waird, G. L., LeRoy.
Meininger, L., Sherburn.	Windmiller & Co., Fred, Mankato.
Mills Lake Nursery, Lake Crystal.	Woodle, C. F., Austin.
Morgan, C., R. F. D., Preston.	

The amount of foreign stock, from France, Holland and Belgium, shipped into Minnesota is increasing each year. The amount already reaching us annually is surprising. In some instances seedlings of varieties very common in Minnesota are imported, on the ground that it is cheaper to pay the European price, transportation charges and duty than to raise them here. For two years the State Entomologist of Minnesota, as in most other states, has been deputized by the Bureau of Entomology, at Washington, to examine all such stock. The day any European stock leaves New York, con-

signed to Minnesota, advice is mailed this office, giving date of shipment, road and consignee. We thus know what is expected, and are on the lookout for these shipments. If they come through in bond, to be cleared at the Custom Houses in St. Paul or Minneapolis, the federal officials at such offices notify us (and they have been very courteous and helpful in this particular) of the arrival of the goods; we authorize the delivery of such stock after the other federal laws have been complied with, and at the same time notify the consignee, nurseryman or florist, as the case may be, and they comply with our request by telling us when the goods are at their institutions ready for examination. As a rule, consignees are very obliging and helpful in the matter of examination, doing all in their power to facilitate the work; realizing it is to their advantage to get rid of any undesirable European pest, such as the Gypsy or Brown-tail Moth, and certain diseases peculiar to European pines, currants, etc.

The Simmons' bill, too long to be printed here, is to come before the present Congress. It provides "for the introduction of foreign nursery stock by permit only, and authorizes the Secretary of Agriculture to establish a quarantine against the importation and against transportation in inter-state commerce of diseased nursery stock, or nursery stock infested with injurious insects; and making an appropriation to carry the same into effect."

A few New York nurserymen are strongly opposing Sec. 8 of said bill, which reads as follows:

"Sec. 8. That whenever it shall appear to the Secretary of Agriculture that any nursery stock or other article described in section three of this Act grown in an infested country, district, department, or locality outside of the United States, or the District of Columbia, and such nursery stock or other article is infested by any seriously injurious insect or disease which is liable to become established in the United States, he shall have authority to quarantine against such importations from said country, district, department, or locality, and prevent the same until such time as it may appear to him that any such insect or disease has been exterminated or is under adequate control when he may withdraw the quarantine."

The bill, with Sec. 8 retained, is being pushed by the Bureau of Entomology at Washington, and is supported in its original form

by the unanimous vote of the American Association of Economic Entomologists.*

From December 1, 1909 to December 1, 1910, we examined 376 cases of European plants imported into Minnesota; and of that number, 130 cases reached the state between July 1st and December 1st, 1910, showing the heaviest shipments to be in the spring. These 130 cases contained 11,080 plants, represented by 9,200 Azaleas, 200 hydrangeas, 75 rhododendrons, 662 palms, 570 syringas (lilacs), and enough other miscellaneous material to total the above figures.

We take this opportunity to express our appreciation of the courteous help received from the officers of the United States Customs of the Twin Cities, in connection with our examination of imported stock, and the almost universal politeness of our nurserymen and florists, who have extended much needed help in these examinations.

Abstract of Minnesota Horticultural Inspection Law.

We receive many inquiries regarding our nursery inspection law. The following points answer these questions, and practically represent an abstract of the law.

1. Inspection is not obligatory. Asked for by nurserymen in order to comply with the laws of states to which shipments are made.

2. The State Entomologist, however, has the legal authority to enter any grounds, public or private, where he has reason to believe that injurious insects or dangerous and contagious plant diseases exist, and if such pests are found there he may establish quarantine regulations or prescribe treatment of infested stock, or both, owner to pay costs.

3. Nursery stock entering Minnesota must be accompanied by a certificate of inspection on every package, signed by the proper

*As we go to press we learn that the Simmons bill has been killed for this session, through the active opposition of a few New York State nurserymen, led by Mr. Pitkin. It is a noteworthy fact that the nurserymen of the country at large are in favor of the provisions of the Simmons bill; but in spite of this, the opposition of a few prominent importers, referred to above—an opposition representing the private interests of a few individuals—has been sufficient to delay action, a delay which we believe is only temporary.

official in the state whence stock was shipped. Carrying companies transporting stock into Minnesota not so labeled are liable. Such certificate is generally honored by the Minnesota entomologist, but he has the right to demand that such shipment be inspected if he deems it necessary.

4. The State Entomologist has the right to revoke a certificate issued by him to a nurseryman when in the opinion of the entomologist there is just cause for so doing.

5. It will be seen from the reading of the above that stock imported from Europe into Minnesota comes under the provisions of the state act.

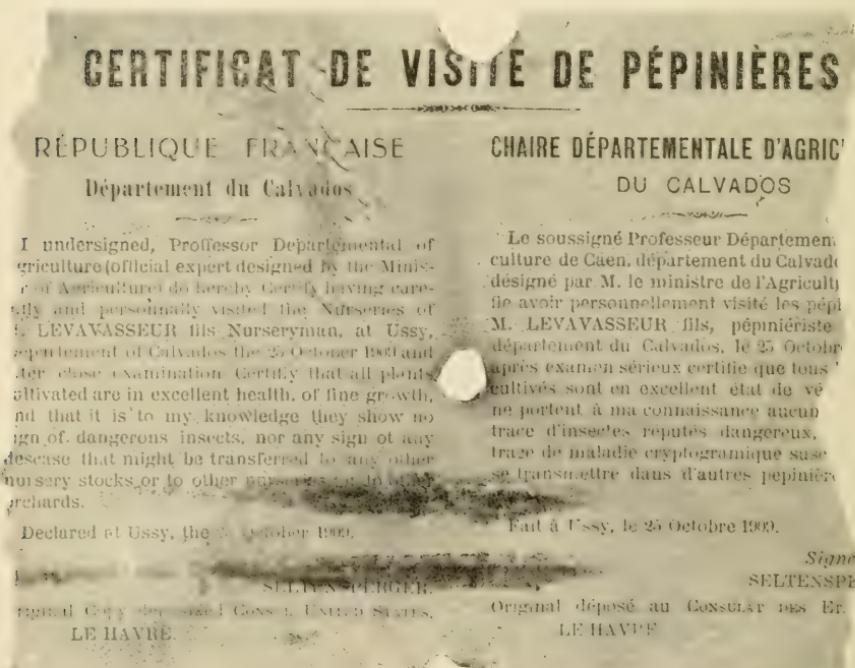


Fig. 17½. Fac simile of certificate on package of French stock, wherein we found nest of Brown-tailed Moth.

SAN JOSE SCALE POSSIBILITIES IN MINNESOTA.**IMPORTANT TO NURSERYMEN AND ORCHARDISTS.**

The San Jose Scale, the most injurious insect to the fruit-raising interests in the United States, has been found in several localities in Wisconsin. In South Dakota this scale is known to have survived two winters, after which the stock affected was destroyed. In Minnesota we have experimentally carried it through two winters.

From the facts above stated it would appear that Minnesota fruit growers have reason to expect this pest sooner or later, and that it is unsafe for them, relying upon our cold winters, to congratulate themselves, on permanent immunity in this direction. In fact though it has never been reported to us, we have no doubt it could be found today in some of the older orchards of the state.

This scale, *Aspidiotus perniciosus* Comst., was brought to this country originally probably from China, over twenty years ago, and is now well distributed over the principal fruit producing sections in the United States. Not only do fruit trees and vines suffer, but almost all deciduous, ornamental shrubs and shade trees, as well as small fruits, and no insect has been the subject of so much and so strict legislation.

To the naked eye, the insect, when in numbers on the bark, is of a general grayish or black color. On badly infested trees it may completely cover the bark. Its presence on fruit causes a discoloration (a reddish mark about the scale), and when on the bark this red color can be observed below the surface in the cambium layer, if one removes the outer bark with a pen knife. In very bad cases the insects impart a greasy feeling to the bark which it covers.

The use of a magnifying-glass brings out certain features not visible to the naked eye. If the scale is thus enlarged ten or fifteen times, one sees that it is for the most part round, slightly raised above the bark and that the center (approximately) is occupied by a

tiny nipple-like elevation. This scaly covering, it must be understood, is simply an armor for the insect, which lives beneath, it being secreted by the insect. While the female scale is round, the male scale is generally somewhat oval. Under this armor, if we raise it carefully with a pen-knife, we find the yellowish insect with its long beak, with which it is enabled to reach and pierce the bark, even though it may be separated from the latter by one or more layers of its fellows.

Its Life History.

The young are born alive in the spring or summer, under the scale of the female, and crawl about for a few hours, after which they insert their beaks into the bark, and then, or even before, begin to secrete the waxy covering which we are wont to call the scale. It is during these few hours of active larval life that the young scales can and do migrate—one means of causing the pest each year to become more widespread. This migration may be active, to other limbs of the same tree, or to other trees whose branches interlace with the home tree, albeit they frequently settle close to the mother scale; or it may be passive, in that the young larvae are carried to other trees on the feet of birds, on the bodies of other insects, or possibly, to some extent, by the wind. Importation on infested nursery stock or scions (and this is the great danger in Minnesota) may be, and is frequently the cause of spreading this pest to a distance, and infested fruit has been, in the past, a very serious menace in districts to which it has been shipped.

The producing-period of the female is said to last for about six weeks, after which she dies. She begins to bring forth young when she is thirty days old, and under favorable climatic conditions may rear three broods or more. Both male and female, as well as the young, pass through the winter in the armored condition, as shown by our illustrations.

The Minnesota Experiment.

A few years ago at the request of a member of the Horticultural Society, we secured cuttings of fruit trees, loaded with this scale, from an infested state, and placed the same in securely-locked cheese-cloth cages, tying the infested scions to a healthy apple and plum tree in each case. The young spread from the scions to the trees.

No aperture was allowed during the spring and summer, on any part of these cages, or at the lower edges. They were kept under lock and key, and no one but the writer had access to the trees within. In this connection it must be remembered that the young scale becomes fixed a few hours after birth. It is, therefore, only during this very short period that the danger of spreading the pest exists in the young stage. During the remainder of the year the scales are securely fastened to the tree. In the winter we have torn the muslin from the top of the cage, thus exposing the insects to all of our weather conditions. In both cages the scales survived the winter of 1907-1908, and were so thrifty in the spring that they were apparently the cause of the death of the trees in one cage. The scales in the cage naturally died after their food supply was cut off by the death of the host-plants. The scales in the other cage went into winter (1908-1909) in fairly good condition, but were found to be dead in the summer of 1909, as were also the trees.

Suggestions as to Preventive Measures and Methods.

However faithful inspectors in scale-infested states may be, it is evidently quite impossible to completely prevent the exportation of every scale insect. Minnesota nurserymen, orchardists and buyers of ornamentals from any states south of us (as well as southeast and southwest) should look upon all such importations with suspicion. According to our present inspection law we are obliged to honor certificates issued by inspectors from other states who, as intimated above, cannot completely eradicate the scale, however conscientious they may be. For that reason we believe it would be wise for our citizens, as a means of self-protection, to ask those from whom they are purchasing stock to have their order fumigated before shipping. This request on the part of purchasers is quite common. In case this is not done, a careful examination of the stock should be made upon its arrival and in case scale is found, or even if one does not find it, fumigation should be resorted to. We are glad to note that this has already been done in the case of scions, by one of our progressive nurserymen. Not that the scale was found upon scions received by him, but it was regarded as a good precautionary measure.

Since the dipping of trees is now looked upon as dangerous, fumigation with hydrocyanic acid gas is regarded as by far the best method. The process is as follows: A house or box should be constructed, containing a known number of cubic feet (100 cubic feet,

or some multiple of that number, is a good size). This is necessary in order to compute the amount of chemicals. A means of top ventilating from the outside should not be omitted. A false floor, if a house is used, or a false bottom, if a box is made, lattice-like in each case, should be so placed that the trees or scions can be placed thereon, an earthen crock or crockery bowl to hold the chemicals being placed beneath. Hydrocyanic acid gas is lighter than the atmosphere, and the reason for placing it below is to allow the fumes to ascend through the stock. Purchase the best of chemicals. The cyanide of potash should be 98 per cent purity, practically chemically pure, and the sulphuric acid should have a specific gravity of 1.83. *Do not use cheap chemicals*, and insist upon getting what you ask for. Wholesale houses in St. Paul can supply the proper materials. Cyanide costs about 25c per lb., sulphuric acid from 1c to 2c per lb.

If scions or roses or two-year-old apple or plum stock are to be fumigated, use the following proportions: Potassium cyanide, $\frac{2}{3}$ oz.; sulphuric acid, $1\frac{1}{2}$ ozs., and water 3 ozs. for every 100 cubic feet of enclosed space. Place the water in receptacle above referred to (never use a metal dish), add the acid, and then drop in the cyanide, immediately closing up the house or box. Allow it to remain closed for forty minutes, then open ventilator and air for 15 minutes before taking out stock. *Not only is cyanide of potash of itself very poisonous, but the above gas is deadly if breathed. Hence the need of extreme care in handling the cyanide, and in making the gas.* The former should be kept in an airtight receptacle plainly labeled "POISON," and out of the reach of children; and one should always bear in mind that when this cyanide comes in contact with the acid, a deadly gas is immediately given off, one good whiff of which might be fatal.

It is best that all stock be dry, or practically so, when fumigated. Do not fumigate stock which for any reason is dripping wet.

Spraying.

It is to be hoped that it may be some time before Minnesota orchardists have to spray for the San Jose Scale, but since there is a wash or spray which is most effective, not only for the San Jose Scale, but for all others, we give it herewith. It is known as the Boiled Lime Sulphur Wash, and it is to be used *only when the trees are dormant*. Make 18 pounds of powdered sulphur (flowers of sul-

phur) into a thick paste with water. Pour this into five gallons of hot water, in which twenty-one pounds of quick lime has been slaked. Boil with frequent stirring, for forty-five minutes, and add enough water to make fifty gallons. This amount could be reduced by reducing the proportions. Iron kettles may be used for boiling. The resulting mixture should be orange or yellow in color. Sometimes steam is used for boiling, and barrels are the containers. There is a method of making this wash without boiling, which, however, results in a less effective compound. It is made as follows: To about ten gallons of water in a barrel add 20 pounds of quick-lime, 15 pounds of sulphur and ten pounds of washing soda; stir frequently for half an hour, and add water to make fifty gallons. Both of these washes have caustic properties, and one should avoid allowing them to come in contact with the skin. Further, they act upon copper very quickly, and therefore, should never be placed in any receptacle made of that metal.

In spraying it is best to use a nozzle which produces a fine mist, The Vermorel or Mistry nozzles are both good for this purpose. A sumner spray of lime-sulphur representing a much-diluted solution, 1-30, or 1-40, is being used with great success as a fungicide; and, in most respects, is far superior to the Bordeaux Mixture. When four pounds of Arsenate of Lead is added to 100 gallons of this dilute form, it makes a very good combined fungicide and insecticide. See in this connection the article on Spraying on page 143 of this report.

THE DANGER OF INTRODUCING THE GYPSY AND BROWN-TAIL MOTHS INTO MINNESOTA.

A WARNING TO FLORISTS, NURSERYMEN AND ALL IMPORTERS OF STOCK FROM FRANCE OR HOLLAND.

The danger of introducing these two European pests into Minnesota should not be regarded too lightly, and all parties importing stock should feel the necessity of affording the inspector every possible chance to see that no nest of Brown-Tail moth, or eggs of Gypsy moth are on the shrubs, plants, trees or vines purchased abroad. Not only would the florists' trade suffer, but all horticultural interests in this state would receive a serious setback if, through the indifference or neglect of an importer, either one or both of these pests should obtain a foothold here.

We are pleased to say that, with a few exceptions, all importers appear willing, not only to report the arrival of stock from abroad but to assist the inspector in every way possible. But it is well to remember that it would only require one case of neglect, possibly, to distribute these pests over the entire state and neighboring states.

The State Entomologist, who is also State Nursery Inspector, has been deputized by the Department of Agriculture at Washington to examine all imported stock coming into Minnesota. Every box of imported stock consigned to a shipping company at New York, and destined for parties in this state, is reported to him from Washington. Later, he receives notice from the collectors of customs in St. Paul and Minneapolis of such consignments as pass through their hands, and immediately communicates with the consignee.

The presence of a foreign certificate of inspection upon these boxes is no guarantee that the stock is clean. Particularly is this true of France, where the inspection, up to recent date, has been almost farcical. The French government has promised to better

these conditions. Inspection in Holland, on the other hand, under the direction of Prof. J. Ritzema Bos, appears to be very rigid, which may account for the fact that up to date we have found no indication of the presence of the Gypsy moth or Brown-Tail moth on stock imported into Minnesota, such stock coming almost entirely from Holland. At the same time even the Holland certificates have not been found infallible, and Dutch stock, as well as French, should be carefully examined upon its arrival. It may be well to add, however, that in many states, both eggs of the Gipsy moth and winter webs of Brown-Tail have been found in French importations this season. As illustrating certain dangerous conditions existing in France, we quote from a report of the chief of the U. S. Bureau of Entomology, Dr. Howard, upon a recent visit to that country.

"Nursery stock for export is, in many cases, grown in the vicinity of hedges and trees infested by Brown-Tail moths, by the Gypsy moth, and by other injurious insects as yet not introduced into the United States, and down to the present time there seem to have been no special precautions taken by nurserymen to prevent infestation of their nursery stock by injurious insects. It seems reasonably sure that the infested nursery stock imported last winter into the United States came from some regions as have just been described. In the late June and July flight of the adult Brown-Tail moths coming from hedges or woods adjoining nursery plantations many of these moths must have laid eggs upon the young nursery stock in the vicinity. These eggs hatched in August, the very small young larvae fed somewhat upon the leaves, webbed up into their characteristic winter nests, and were sent with the seedlings to America. The nests are noticeable, and only extreme carelessness, indifference, or ignorance on the part of the French exporters could have allowed them to be packed without removal."

We have found, in the course of an examination of imported stock, one nest of young Brown Tail moths, which was promptly taken care of. We do not believe that anything in the way of a European insect pest has slipped by us in our inspection of something over two hundred boxes in 1908 and 1909. If any specimens of Brown Tail moths or eggs of Gipsy moth have been introduced here, it is because of the thoughtlessness of some importer, who may have unpacked and distributed his stock without notifying us. There are doubtless but few cases of this kind, and it is probable that all florists, nurserymen, and other importers prefer to go to the slight inconvenience of notifying the State Inspector, and having him go over the stock at time of unpacking, rather than having a federal law created which would oblige shipments to be unpacked and examined at port of entry, occasioning, frequently, delay and loss. Let me then urge once more upon all importers of foreign nursery stock, trees or

ornamentals, in the interest of keeping the state free from these pests, and in the interest of good horticulture and floriculture, and for the sake of business prosperity, to notify the inspector at St. Anthony Park of the arrival of and time of unpacking of consignments from Europe.

To familiarize importers with the appearance of these two destructive pests in their various stages we append pictures of both of these insects in their various stages. We are indebted to Prof. E. D. Sanderson of the New Hampshire Experiment Station for the use of these cuts, and his courtesy is gratefully acknowledged.

Gypsy Moth.



Fig. 18.

Egg cluster; generally on bark of tree. Light yellowish. From August to May. Egg masses should be soaked with creosote in fall, winter or early spring.



Fig. 19.

Caterpillar: Dark color; double row of ten blue spots on back anteriorly, posteriorly twelve red spots.



Fig. 20.

Gypsy Moth, female: Moth whitish; wings imperfectly streaked with black or blackish; spread of wings about two inches. Does not fly.

Winter passed in egg stage. In this condition (Fig. 18) they are introduced into the United States.

Brown-Tail Moth.

Fig. 21.

Egg cluster on under side of leaf; dark yellow or brown; found in July.



Fig. 22.

Caterpillar: Yellowish or orange. Row or white spots or markings along each side of body, middle line of back; posteriorly two bright, red spots,



Fig. 23.

Brown-tail Moth, female: Pure white, tip of abdomen brown. A strong flier, and attracted to lights.



Fig. 24.

Winter nest: Small caterpillars in mass of leaves and silk at ends of twigs, from which they emerge in the spring.

This is the stage (see Fig. 24) in which they reach Minnesota and other states on nursery stock and ornamentals, and is what the nurserymen and florists should look for, and what the inspector looks for at time of unpacking stock. THESE NESTS SHOULD BE CUT OFF AND BURNED IMMEDIATELY. IF LEFT ANY LENGTH OF TIME IN STOREROOM WHERE IT IS MODERATELY WARM THE CATERPILLARS MIGHT CRAWL OUT AND IN THAT WAY BE OVERLOOKED.

HOUSEHOLD INSECTS.

The House Fly and the Clothes Moth.

It is the intention of this division of the Experiment Station to issue circulars of information regarding our household pests—flies, fleas, clothes moths, cockroaches, etc. These circulars can be obtained free of charge by writing the Entomologist at the Experiment Station. The present circular is the first of the series.

The House Fly or “Typhoid Fly.”

The name “Typhoid Fly” has been proposed for our common house fly because, although a large percentage of typhoid comes from our water supply, this insect, by carrying germs of typhoid and depositing the same on or in food, has been proved to be an

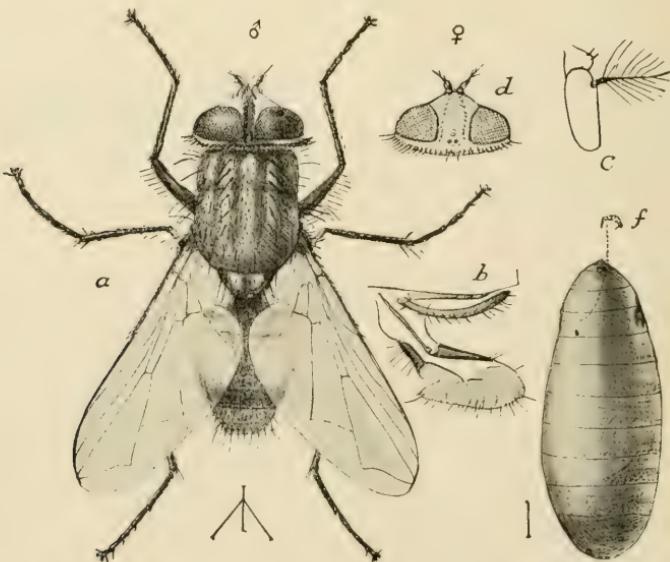


Fig. 26. The House Fly or Typhoid Fly, *a*, adult male; *b*, proboscis and palp of same; *c*, terminal joints of antennae; *d*, head of female; *e*, puparium; *f*, anterior spiracle, all much enlarged. After Howard, Bur. Ent., Dept. Agriculture.

active means of spreading this disease. It is claimed that there are in this country annually over 200,000 cases of typhoid, about one-eighth of these cases resulting fatally.



Fig. 27. Eggs of House Fly much enlarged.
After Metcalf, North Carolina Dept. of Agriculture.

Not only is this insect a menace to children and adults in this connection, but is also a disseminator of various other deadly diseases, such as cholera (the cholera germ as well as the typhoid germ having been found in fly-specks), tuberculosis and numerous other dangerous maladies. This filthy insect, then, is now known to be a serious menace to the health of human beings, and an active campaign has been inaugurated against it. The special danger of its presence in a house lies in the fact that in addition to the germs being able to pass through the alimentary canal and still retain their vitality, it can carry upon its feet and upon the hairs of its body thousands of germs which, introduced into the intestinal tract of man, may cause typhoid and other intestinal diseases, as well as consumption, and further be a cause of inoculating wounds or abrasions upon the skin. It will therefore, be seen that the house fly may be the means of transporting disease quite a distance, and may possibly be the cause of an epidemic suddenly appearing in a locality for which no reason can be assigned.

The following quotation from a leading entomologist, while not pleasant, is certainly suggestive, and deserves a place in any article on the house fly.

"In the course of a few moments a single fly might crawl over excrement, sip from a glass of milk or water, and merrily chase across a dish of mashed potatoes and other human food. It may visit a dead and decaying animal, or sport about the mouth of a reeking sewer, and in the next five

minutes sit upon the edge of a glass of jelly or alight in the sugar bowl. It may visit the body of an animal that has died of anthrax, and a little later brush across a lacerated hand or cheek."



Fig. 28. Larva or maggot of House Fly, natural size and enlarged. After Metcalf.

privy. An abundance of intestinal diseases is contemporaneous with the greatest abundance of the house fly, that is, during the hottest period of mid-summer, showing a connection between these two. As many as one hundred thousand bacteria, which came from matter voided from the intestine, have been found to be present on one fly. In our late war with Spain it was declared on reliable authority, and from actual data, that while we lost only two hundred and fifty men, practically, by bullets, we lost five thousand through the agency of house flies. This refers to criminal negligence in connection with the hospitals; the trenches containing the excrement of typhoid patients not being covered, and the flies, after crawling over this germ-laden matter, flying to the mess-tables of our soldiers, and polluting the food thereon.

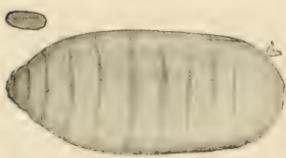


Fig. 29. Puparium of House Fly, natural size and enlarged. After Metcalf.

The house fly passes the winter in some snug retreat, either as a perfect insect, or as a pupa, appearing on the scene in the first warm days of spring. The female lays a hundred or more eggs, each egg being about one-twentieth of an inch in length, which quickly hatch

into maggots. These become full grown in about six days. The pupal or resting stage lasts six days. There are, therefore, from ten to twelve days from the egg to the perfect fly. They breed primarily in fresh horse-manure, hence the more of this waste that is allowed to accumulate, and the nearer it is to the dwelling house, the more will said dwelling house be troubled by flies. They also lay their eggs in other kinds of manure, in decaying vegetables, in sewage, in waste from the human intestine, and in various kinds of filth. They do not bite, but they lap or suck up food in a liquid state. When one sees a fly resembling a house fly on his hand, and

Bread, pastry, candy, fruit or vegetables exposed for sale without being covered, are subject to visits of flies, which may previously have crawled over the filth of the street or sewer or

feels the sharp sting caused by the insect's biting or stabbing, he should realize that this is a stable fly, and not the house fly. Furthermore, when big flies and little flies are observed upon a window pane, the little flies are not to be regarded as the young of the big flies, but belong to different species, since flies and other insects never grow when they are in the final or perfect state.



Fig. 30. Petri dish containing agar over which a Fly, caught on the experiment station grounds, was allowed to walk. The white spots are colonies of bacteria coming from germs left by the Fly when crawling over the jelly. Original.

When we consider the filthy location of the eggs of the house fly and know its food, it is no wonder that we turn with disgust from any dining-room table where these creatures are in evidence, and we are not surprised that, after crawling over such filth, or over the saliva of a consumptive, they can and do carry the germs of typhoid and tuberculosis.

It is a matter for congratulation that the housekeepers of Minnesota are keenly alive to the desirability of keeping flies out of their houses. One occasionally finds a kitchen infested, or a dining-room infested, but as a rule our houses are well protected in this particular. It would seem, from facts in our possession, that to allow house flies to enter a dwelling-house or a hotel, amounts to almost criminal negligence.

Some Natural Enemies of the House Fly.

It addition to some insects which attack the Typhoid fly, such as the Dragon Flies, and the Robber Flies, which may make some inroads on their ranks, we find a tiny mite attacking them, as shown in Fig. 32, and in the autumn a very common fungous disease, the spores of which find suitable nourishment in their bodies. Flies killed by this disease, as shown in Fig. 31, are often seen hanging on window panes with this vegetable growth around them.

REMEDIES. Screens on windows and doors, sticky fly paper (preferable to poisoned fly-paper), the doing away with manure-heaps, the covering of slops and of filth, not leaving them to pollute the neighborhood of the house. Swill barrels should have tight covers. Some farmer's wives put sticky fly paper on the outside of their screen doors at the top and this catches the flies which gather on the doors. Intestinal discharges from a patient suffering from



Fig. 31. Fly killed by a fungous growth.



Fig. 32. Fly attacked by mites. Lugger.

typhoid or any other fever, or any infectious disease, should be sterilized before being emptied into sewer or cesspool. Stables should be, where possible, located at a distance from the house. A reason for not letting horse manure accumulate is very evident, and some stables are so constructed that this is kept in a covered compartment until removed, or treated frequently with a substance which will kill the maggots of the house fly. The following poison we have found to be good and at the same time sterilizes the fly; two teaspoonfuls of formaldehyde in a pint of water placed in shallow dishes. Do not buy groceries or meats from any store where flies are tolerated. Fruits and candies should be screened from flies; keep them away from the baby or its milk bottle. Another remedy is that of fumi-

gation. Pyrethrum placed in a pan on a hot stove and allowed to smolder but not break into flame, will stupefy, if the room is tightly closed, all the flies therein, which should be carefully swept up afterward and burned, otherwise some will revive. Pyrethrum or Persian insect-powder loses its strength upon being kept; and in buying one should be particular to get fresh powder, or what has been kept in tightly sealed receptacles.

The House Fly is a menace to the health of your children and yourself. Its new name—"Typhoid Fly," is significant!

THE CLOTHES MOTH.

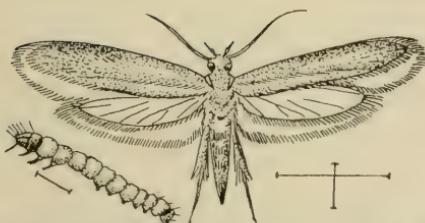


Fig. 33. Southern clothes moth, *Tineola biselliella* and larva or "worm," enlarged. Lines on right show natural size of moth with wings spread. After Riley.

There are two species of clothes moth common in different parts of the United States, but we have come in contact with only one in Minnesota, namely, *Tineola biselliella*. This pale yellowish moth is about a quarter of an inch long, and its larva attacks not only woolens and

furs, but also feathers. The writer has observed the moth flying in his residence as early as March 6th. It undoubtedly lays its eggs prior to that date, since full grown larvae were found on March 16th. The egg is visible to the naked eye, and can be dislodged by shaking or brushing the cloth or fur in which it is found. Eggs kept under observation in our laboratory, hatched in six and seven days, one female laying several eggs. One of these eggs measured under the microscope was found to be .02 of an inch long by .01 of an inch wide, of a pearly-white color. The young worm, or larva shown in Fig. 35, was one-twentieth of an inch long when about twenty-four hours old.

This is a very troublesome pest in Minnesota, as all housekeepers know. It is well to remember that camphor, naphthaline, moth balls, etc., kill neither the insect nor its eggs, but act merely as repellents. Further, storing furs and woolens in a chest, cedar or otherwise, the odor of which may be repulsive to the insect, would be of no avail if there were eggs or larvae of this moth in the

same when so stored. As a rule clothes, which are used occasionally or brushed or shaken in order to dislodge any eggs thereon, are not appreciably injured. If the presence of eggs or larvae is suspected in any fur or other material, a mild beating and brushing of such article will remove most or all of them. Woolens or furs hanging in an unvisited part of the attic, or rugs and similar material stored away and not examined frequently are prolific sources for breeding moths in a house.

When one is absolutely sure that no eggs or larvae (worms) are present, a very good practice is to store articles in pasteboard boxes which are afterward thoroughly sealed by pasting paper over the cracks. It is usually not safe to let woolens, furs or feathers remain undisturbed a long time in an ordinary trunk, since, as a rule, such trunks are not moth-proof.

Cold storage is much resorted to for the preservation of furs during the summer, and this is quite a feature in the business of many of the cold storage plants in cities. The pest cannot work in a temperature below 40 degrees Fahr. Frequent beating of furs,



Fig. 34. Egg of Clothes Moth in woolen goods. Much enlarged. Original.



Fig. 35. Larva of Clothes Moth as seen under microscope. It is in this form that it eats woolens and furs. Original.

furniture, curtains, woolens, etc., during the spring and summer, say in May, June, July and August, is helpful. The writer in his own house has practiced the following method for several years with marked success. A galvanized iron chest was constructed, about two feet square at the ends, and three and a half feet long. The cover fits in with a flange, and a strip of felting is glued on around the edge which rests on the edge of the chest when the cover is in place; six hooks on the cover fasten into eyes soldered on the chest, and

serve to keep the former tight. Into this receptacle in the spring goes all of our clothing not to be used during the summer, and which is attractive to moths. At the same time in a saucer-like dish placed on top of the clothing is poured four tablespoonfuls of bisulphide of carbon, and the chest closed. It should not be opened for any purpose for three or four days. We repeat this performance about ten days later, since the vapor fatal to the larva does not, we believe, kill the egg, and perhaps once or twice more at intervals during the summer. These latter fumigations are probably not necessary, but would kill any insect life, should a moth, by accident, have crawled in. This vapor, heavier than air, sinks through the clothes stored in the chest. It is explosive when mixed with the atmosphere, and no light of any kind should be brought near it. Bisulphide of carbon may be purchased in pint cans. It in no way injures the clothes. A tight closet made for the purpose or any perfectly tight chest might take the place of the iron box above described.



Fig. 36. A new suggestion as to Fly Traps. The garbage can is so constructed that flies can enter. Then, seeking the light they fly into the cage above. Hodge.

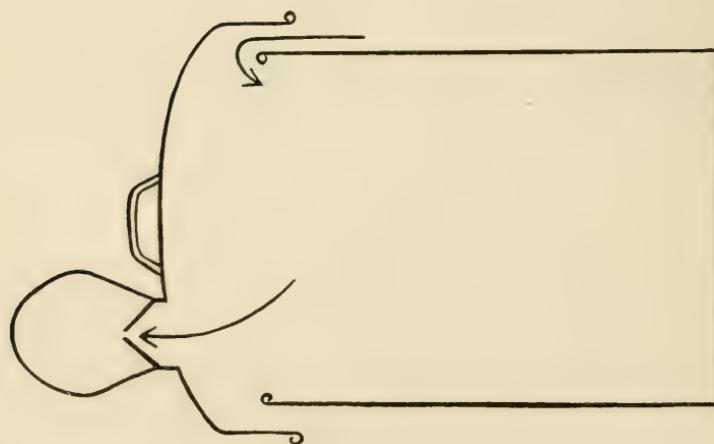


Fig. 37. Diagrammatic vertical section of "Hodge's Fly Trap."

FURTHER WORK UPON THE STALK BORERS.

Papaipema sp.

Fig. 38. General view of plots used in experiments with Stalk Borers.

The eggs mentioned and figured on page 153 of the Twelfth Report were laid on or about September 17, 1908. On September 22nd they had become brownish gray in color. On Sept. 26th they were photographed; the photograph being the one that appeared in the Twelfth Report. On May 20th, 1909, these eggs began to turn dark, and on May 24th and 25th a considerable number of them hatched. Many of the caterpillars made their way to the leaves of seedlings of the giant bur-elder which happened to be in the cage, and in these leaves they acted as leaf miners, making galleries. Drawings of this first work of *Papaipema* larvae were made, and also photographs taken by Mr. Ayer. These galleries were made in

the middle of the leaves, the seedlings being scarcely one inch tall at this time. A drawing of one of the young worms was also made. They were about $2\frac{1}{2}$ mm. long at this time. In hatching they left large holes in the sides of the egg-shells. These eggs continued to hatch until the 29th of May, and there were in all about 100 caterpillars which hatched from them, and the leaves of several young giant bur-elder seedlings, which were in the breeding-cage at the time, were completely riddled by the mining of these caterpillars.

The caterpillars in their earlier stages have a looping movement, much like that of *Geometrid* larvae. All the larvae, which had not



Fig. 39. Partial view of plots used in experiments, showing barriers, etc.

at this time established themselves as miners in the leaves of seedlings, were taken and placed on selected seedlings of giant bur-elder; these seedlings being all in good condition on May 28th. The larvae were placed on these seedlings at about 5:30 P. M. on May 28th, and were examined about 8 A. M. May 29th, and were found to have already established considerable galleries in the leaves of the seedlings. There were eighty-four larvae in all placed upon seedlings in this way.

Some of the leaves were photographed, showing the leaf-mining work, with mines well formed, and some of the larvae in them.

On June 2d the larvae were showing a noticeable tendency to work down toward the bases of the leaf blades, and even to work into the leaf petioles to a considerable extent. The largest of the giant bur-elders were about four inches tall at this time. Leaves showing this mining work, and two of the larvae, were bottled in alcohol and formalin. By June 4th the larvae had in many cases taken to boring into the stalks of the young bur-elders, the tallest of the weeds at this time being about five inches tall and about one-tenth inch through at the base. By July 7th many of the first plants attacked were dead, having been completely destroyed by the



Fig. 40. The larva of *Papaipema* sp. mining in leaf of Giant bur-elder seedling. Franklin.



Fig. 41. Larvae of *Papaipema* sp., mining in leaflet shown in Fig. 40, much enlarged. Franklin.

borers, and many of the borers were in their second plants. The stalks of the second plants attacked were at this time about twenty-four inches long on the average, and the galleries in them averaged about four inches in length, ranging from two and one-half inches to six inches. By July 22d the caterpillars had reached a length of from one inch to one and one-quarter inch, the galleries much longer than the longest ones were on July 7th. One plant was found harboring two of the caterpillars. Its stem at this date was twenty-three inches long. The entrance

hole of the lower caterpillar was nine inches above the ground, and the upper one was thirteen and one-half inches above, and the galleries went upward from the entrance-holes. On August 17th none of the larvae which had been reared from the eggs were found present in any of the plants. Some of the borer holes were entirely vacant, and a few had pupae in them. This shows that a *Papaipema nitela* larva naturally attacks but two plants in the course of its life.

Papaipema nitela.

The last larva of this species seen during the season died in captivity on September 7th, twenty days later than the last larva pupated in the season of 1908. The first pupa was found on August 11th (three days later than last year). The first moth of this species emerged in captivity on August 24th (one week earlier than last year). The last moth emerged on October 1st.

The average length of the pupal stage this year was about the same as it worked out to be last season. This season it varied from twenty to twenty-six days, the average being twenty-three days. This species was reared during the season from the following food-plants: Nicotiana, Lamb's Quarter, Tomato, Giant Ragweed, Cockle Burr, Giant Bur-Elder, Peony, Burdock (the Giant Bur-Elder was this year, the same as last, the most badly attacked food-plant).

Typical *Papaipema nitela* larvae were found in the stalks of giant ragweed as follows: One with an entrance-hole ten inches from the ground, burrow seven inches long, ascending. This was found on August 1st. Two larvae of this species were found in giant ragweed with their entrance-holes twenty-one inches above the ground, and with burrows five inches long, ascending, and three were found on the same date with the entrance-holes six feet above the ground, and burrows three and one half inches long, and also ascending. On August 1st there were found twelve *Papaipema nitela* larvae in a single giant ragweed stalk three feet high. Some were in the stalk proper, and some were in the branches. We found many burrows formed apparently by both *Papaipema nitela* and *Papaipema cataphracta* larvae in wild hemp and other plants on September 3d. This goes to show that a large percentage of the larvae of these species go into the ground to pupate. The burrows which were formed earliest were at this date nearly closed up by the growth of the plant on the interior of the stem.

Papaipema cataphracta.

Larvae were first found working on young box elders on July 14th. From this date on they were found very commonly throughout their active season. The last larva found pupated in captivity on August 23d. The first pupa of this species was found on August 7th (two days earlier than the earliest date last year). The first moth in captivity emerged on August 30th (nine days earlier than last year), and the last one on September 27th (five days later than last year). This species was this year reared from the following food plants: Burdock, Box Elder, Giant Bur Elder, Hollyhock, Cosmos, Peony, Larkspur, Dahlia, Thistle, Aster, Ragweed and Tiger Lilies. Strange to say, it was not found at all this year in either Hemp or Golden Glow. It was found in greatest numbers in Burdock, as it also was in 1908. The average number of days passed in the pupal stage, as computed from the records of a large number of individuals this year, was twenty-nine, the range being from twenty-six to thirty-three. It will be noticed that this is quite a little longer than last year's average of twenty-two days (see Twelfth Report of the Minnesota State Entomologist).

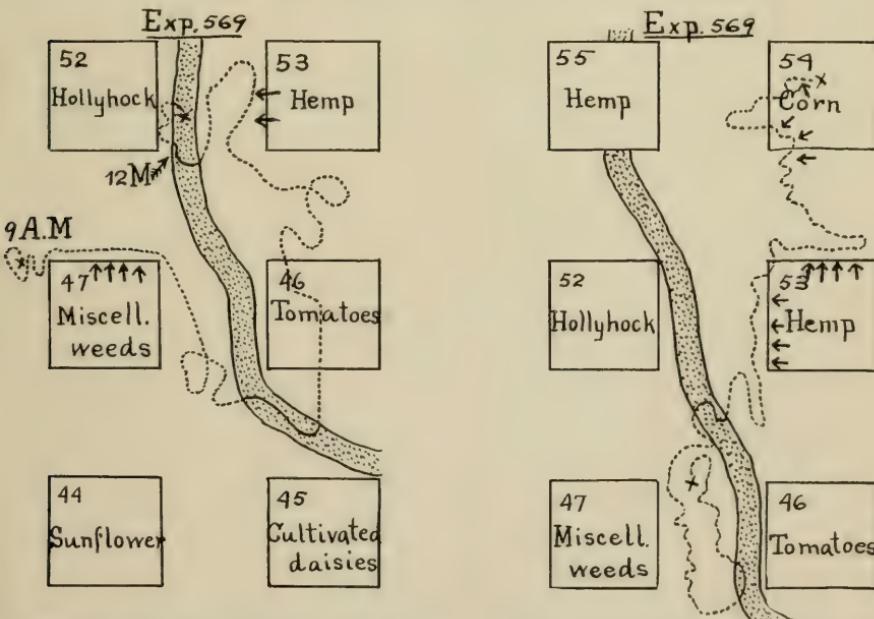


Fig. 42. Diagram showing endurance of larva. The dotted lines indicate course taken by larvae. Each plot 4 feet square. The broad shaded line represents a narrow ditch, about 10 inches wide. The arrows show where effort was necessary to keep larva from entering favorite food plants.

The specimens of this species found in thistle were observed to always enter at the bases of the leading leaves at the summits of the stalks, and to bore downward; the burrows at their lower extremities ending blindly. A Hollyhock stalk containing two larvae of this species were discovered, which had three entrance holes in it. The lowest of these was one foot from the ground, and the highest was four feet, two inches from the ground. All these openings were connected by one continuous burrow, which was three feet, five inches long. Both larvae measured at this time about one and one-fourth inches long. The burrow did not extend at all below the lowest hole, this showing that the larvae had, as is usual with *Papaipema* larvae, burrowed upward.

General Observations.

Larvae were placed upon various kinds of ground, and their movements watched for several hours, in many cases until many of the larvae stopped from exhaustion, and finally died without being allowed to enter the food-plant. These observations go to show that the larvae seldom, if ever, travel any considerable distance in a straight line from the place where they first hatch.

In tracing the course of these larvae, and in measuring the distances traveled, the courses were marked out as they traveled along, by lime scattered on the ground. The caterpillar which made the best record in actual distance traveled seventy-nine feet before exhausted, but when it finished its traveling it was only fourteen feet in actual distance from its starting-point, its course having been very irregular. Another larva traveled in actual distance fifty-six feet before being exhausted, but reached a distance of only sixteen and one-half feet from its starting-point. Still another traveled a total distance of fifty-five feet, and ended twenty-four feet from its starting-point, this being the farthest distance reached from the starting-point of which we have record. The larvae that made these records were practically full grown. See Fig. 42.



Fig. 43. Larva of *P. nitela*, taken from leaf mine, enlarged about 12 times. Original.

Observations Made in Parks of Minneapolis and St. Paul.

Several days were spent in examining flower-beds in parks of Minneapolis and St. Paul, all the principal parks being visited. In

most cases the beds were found to be entirely free from the attacks of stalk borers; and when they were not free, it was because the infested beds were located in some neglected corner of the park, near some weedy patch; it being evident in these cases that the larvae had first hatched from eggs laid on the weeds, and later found their way into the cultivated flower-beds. In talking with those who had charge of the flower-beds, we discovered that these beds were given far better attention than is commonly given to flower-beds of private individuals. Most of the perennials in the flower-beds of the parks are either taken up in the fall and put out again in the spring, or else—in the case of such plants as Golden Glow, which are left out-doors during the winter—the beds are raked very carefully, and the old dead stalks and stubble all destroyed late in the fall; and, of course, this treatment would naturally get rid of the eggs of any insect which might have been laid upon them during the early fall.

This, together with the observations on the number of stalks infested by a single caterpillar, and on the distance to which caterpillars travel, makes it very evident that the best means of combating these pests is to take good care of the beds; cleaning them up well late in the fall, after time of egg-laying of this species is over, and clearing up the weeds and keeping them cleared up in the vicinity of flower-beds. It is particularly desirable to clear up the weeds that start during the latter part of May, and during June, in such localities, because then the young larvae, which are at that time mining the leaves of the small weeds, are easily destroyed, and if the young weeds are destroyed in the vicinity of the beds at this time it is not likely that larvae will go from other weeds at great distances to attack plants in the beds. Of course, many private gardens are so placed that the matter of weeds is one which is difficult to control, because the flower-gardens are in close proximity to land belonging to other persons than the owner of the flower-gardens, and in such cases the owner of the flower-garden cannot go upon the other person's land and clean up his weeds for him. In such cases it is desirable to have some means at hand by which the borers may be kept out of the flower-garden, in spite of the proximity of the weedy places.

Experiments have been conducted, during the season, to discover some means of preventing larvae from getting into flower-beds in this way. Many different plots, adjoining different sorts of plants which are commonly infested by these borers, were laid

out. Some were used as check plots, and some were surrounded by various barriers to keep out the larvae. The plots contained the following food plants: Hemp, Peony, Dahlia, Corn, Potatoes, Tomatoes, Golden Glow, Asters, Tiger Lilies, Hollyhocks, Giant Bur Elder, Giant Ragweed, Burdock, Daisies and Sunflowers. Amongst the barriers tried were strips of lime six inches wide thrown around the entire plot; ditches dug with perpendicular faces next to the plots all the way round; tarred paper strips surrounding the plots, laid flat on the ground, six inches wide, covered with tangle-foot; galvanized iron strips stuck in the ground edgewise, alone, and painted with tar, painted with tangle-foot; shingles stuck in the ground endwise and overlapping one another, completely surrounding the plots alone, and painted with tar, with tangle-foot; plots also completely surrounded by strips of creosoted sawdust, six inches wide; one-eighth inch boards edgewise, alone, and painted with tar and tangle-foot.

Larvae were placed amongst these plots and were allowed to crawl around, and were watched; and it was found that only those barriers which had a coating of tangle-foot in some form were successful in stopping them. It was also found that only barriers which extended about three inches above the ground kept the tangle-foot free enough from dirt for any length of time to be of value. The shingles had a tendency to get out of place badly, leaving cracks between them; and it was found that, everything considered, the best barrier was one made of thin boards about five inches wide, about one-eighth of an inch thick, placed in the ground edgewise, and smeared with tangle-foot on the side away from the plot. Plots of ground were also surrounded with these barriers, and the painting with tanglefoot, tar, etc., reversed, being placed on the inside, and the caterpillars placed on the inside, to see if they could get out of the plot over the barriers; and here, too, the only thing which was capable of stopping them satisfactorily was a complete barrier like the thin board smeared with tangle-foot. It was noticeable that the caterpillars which were placed among the plots in the insectary garden, and their movements watched for some time, would, when within about two feet of their favorite food-plants, show a very strong determination to go



Fig. 44. Pupa of *P. nitela*.
Original.



Fig. 45. Pupa of *P. caphracta*. Original.

directly toward the food-plants, and they had to be continually turned away from them. This suggests that possibly a barrier of weeds might be placed around a garden in a regular line, thus providing the caterpillars hatched outside the garden with food, and so making it unnecessary for them to travel to the flower-beds. Of course, these weeds would have to be burned in the fall and others be set out in the spring sometime during the last of May or early part of June, and the stumps of these weeds would have to be destroyed in the fall, so that there should be no trace of them on which the moths could lay their eggs at that time of the year.



Fig. 46. Imago of *P. cataphracta*. Original.

Summary.

Provided one's garden is free of weeds, particularly burdock, ragweed, bur-elder and the like, and last season's growth has been carefully removed and destroyed, one can protect an entire garden from the attacks of the stalk-borer by a six or eight-inch board placed around the outside, the lower edge an inch or more below the surface of the ground, and the upper edge three inches above the ground; said board to have on the outside a band of some material which will either remain sticky or be kept sticky by separate applications, from June 1st to August 1st. Tangle-foot has proven satisfactory in our experiments. The tangle-foot should be put on an inch or so above the ground, so that it could not be easily coated with earth by the spattering occasioned in the event of heavy showers; and whatever sticky substance is used, it should be of such a nature as to either remain sticky, or be kept sticky by several applications, from June 1st to August 1st.

The fact that the larvae show a strong tendency, when within about two feet of their favorite food-plants, to go to said food-plants directly, suggests that possibly a barrier of weeds might be placed around a garden, thus providing the caterpillars outside the garden with food, and making it unnecessary for them to travel to the flower-beds. These would have to be burned in the fall, of

course. They would have to be in position during the last of May, or early part of June.

In some cases it might not seem desirable to treat a whole flower-bed, or a whole garden, for these stalk-borers, and it might only be desirable to prevent their getting at a few plants which might be decidedly more valuable than the rest. In such cases it has been found that the bases of the stalks of the plants may be smeared with tangle-foot for a distance of about three and a half inches up from the ground. In such cases if there are leaves around the base of the plant, or (if the tops of the plant lie against other plants near by) these portions of the plant which would allow caterpillars to crawl from the ground over the tangle-foot, or from other plants on to the protected plant, should be cut away and destroyed.

Parasites.

These two species appear to be extensively parasitized, since we have reared many individuals of Tachinids from them. From *P. cataphracta*, *Hypostena variabilis* Coq., and from *P. nitela* also, an *Exorista* sp., also *Masicera myoidaea* Desv. in large numbers; the last named being identified by Professor Aldrich. From a breeding-cage containing both species we reared what I regard as *Ichneumon laetus*, and evidently *Ichneumon orpheus* Cress. From some material emerging from the pupa of *P. nitela*, Professor Aldrich also named for us an Ortalid, *Chaetopsis aenaeus* Wied.

We have considerably more parasitic material from these two species, of at least one genus and parasitic.

Dr. Franklin had charge of this work and the above represents his report in this connection.

NOTES ON THE ENGLISH GRAIN PLANT LOUSE.

Macrosiphum granaria, Buck.

This is the louse which is so common on wheat in Minnesota. Specimens of this species were kept under observation during the fall of 1908, up to December 10th, and as late as this a large number of specimens, kept under natural out-door conditions, were still found to be alive. No males were found at this time. Only wingless viviparous females were present, and young females in all stages; no eggs were found.

The insects had been kept on winter wheat, and the temperature had been down at this time as low as five degrees Fah. below zero. These insects were kept on for some time after this, but in time succumbed to the cold weather, and all perished.

On April 5th, 1909, a considerable amount of sod from a field of winter rye, which during the late fall of 1908 had been very heavily infested all over with *Macrosiphum*, with the soil for four inches below it, was brought into the insectary, and put in a tight but airy cage, built for the purpose of stout pieces of wood and muslin. It was put near the center of the warm room of the insectary. This was kept and examined as late as June 30th, and no *Macrosiphum* appeared.

The material brought in from the rye-field completely covered the ground underneath this cage, and the fact that the cage was 3 feet 4 inches wide by 6 feet 5 inches long, showed that a considerable quantity of sod and soil was brought in.

While the material in this cage was being so closely watched, the rye-field from which the material came was also examined and swept from time to time in April; then every few days during May, up to as late as the 25th, but no *Macrosiphum* was found in the field until May 29th. On this date Mr. Stafford, by sweeping with a fine collecting-net, captured an immature wingless nymph on the west side of the rye-field. On May 31st Mr. Stafford collected

five specimens by sweeping this field. Most of these were winged. On June 2d he collected seven winged and one nearly mature wingless specimen of this species, and on June 4th, he collected four winged and one wingless by sweeping. On June 9th he collected one winged and one-half grown nymph by sweeping with a collector's net. There had been recent rains, and insects of all kinds were scarce on the rye on this date. On June 12th three winged and one wingless *Macrosiphum* were collected. On June 14th a considerable amount of sweeping failed to collect any specimens. On June 15th twelve wingless forms were found by sweeping. On June 21st seven wingless forms were found, but no winged forms. On June 25th a dozen wingless forms in all stages, and one winged adult were found, and on this date the first colony was discovered by examining the rye without the aid of the collector's net. After this the rye was examined and swept from time to time with about the same results as before, only a very few specimens being found, and on July 24th, the rye having been cut on July 21st, the field was examined for the last time. The stubble was swept with a net thoroughly, but we were utterly unable to find any *Macrosiphum*. The shocks of rye and stubble were perfectly dry at this time.

The fact that so few *Macrosiphum* appeared in this field after the heavy infestation of the previous fall, and the fact that we were unable to rear any specimens from the sod and earth brought in from this field in a cage in the insectary, leads us to have some belief in the theory that this species comes in from the South every year, and that it does not pass the winter in Minnesota in any form. The early date on which it was found would make it seem probable that, if it does come in this way, it is brought in from long distances by winds. But if this is the case it must have been brought in, this season, in rather small numbers, as the numerous sweepings in the rye-field indicate.

On April 15th two shields of canvas, each 5x8 feet, were placed on the water-tank of the Experiment Station. In this position they were sixty feet above the ground, and as the tank is located on a hill, they were considerably higher than most of the surrounding country. These shields were covered with tree tangle-foot. The purpose of placing the shields in this position was to find out what sorts of insects were carried by the wind in considerable numbers, and to discover if *Macrosiphum* was among them. The shields were examined from day to day until July 6th, when the tangle-foot

had become so dried as to be of little use. Insects of many different kinds were found, but no plant-lice among them.

A similar canvas shield was raised on a frame of iron piping, on May 10th, on the southeast corner of the rye-field above mentioned. The shield was faced to the southeast, and held in place with ropes attached to the iron frame. This was examined from time to time up to July 13th. Insects of many different kinds were found upon it; among them, on June 25th, many winged specimens of aphid, *Callipterus punctata*, which breeds on oak. As there were no oaks within 300 yards of the shield, these plant-lice must have been carried a considerable distance directly by the wind. No *Macrosiphum*, however, were found on this shield at any time.

On July 15th a new shield was placed on the tower, in the position occupied by the old ones above described, and was examined from time to time up to September 8th; but no aphids were found at any time upon it, so that the work with these shields, as far as plant-lice in general and *Macrosiphum* in particular are concerned, is mostly negative.

**THREE BAD INSECTS IN MINNESOTA NURSERIES
AND ORCHARDS.**

The Oyster-shell Scale or Apple-bark Louse, the Scurfy Scale,
and the Buffalo Tree Hopper.

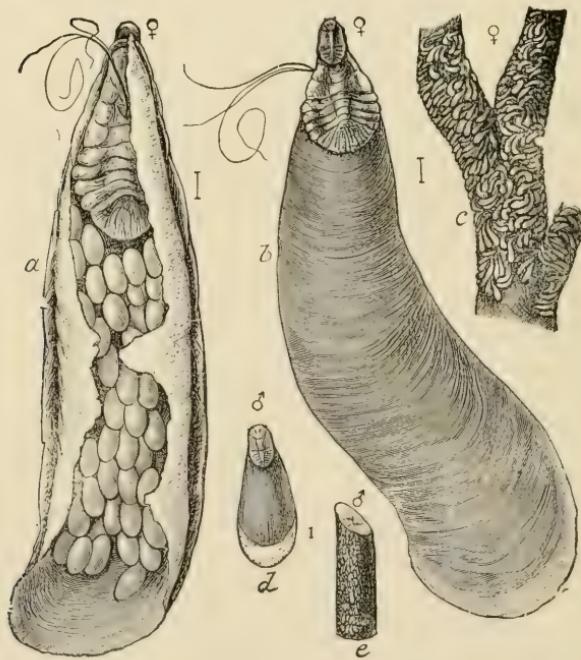


Fig. 47. The Oyster Shell Scale. After Bureau of Entomology, U. S. Dept. Agriculture.

The Oyster-Shell Scale and the Scurfy Scale appear to be on the increase in this state, and both capable of injuring the trees of the nurseryman and the orchardist.

The first named, brownish in color, is at once recognized by its elongated "oyster-shaped" appearance. It infests not only the apple, but other fruit trees, as well as lilacs and various other ornamentals. The eggs pass through the winter under the scale, and hatch in the spring—May or June in Minnesota. The tiny young crawl over the tree for a few hours, and then become fixed, and secrete the scale which is to cover them for the remainder of their existence.

Spraying with a strong lime-sulphur solution, at a time when the trees are dormant, has been recommended; but perhaps as good or a better way is to spray several times with a mild lime-sulphur solution, or with kerosene emulsion, or with so-called whale oil soap, at the time when the young scales are crawling over the tree. A very effective thing to do would be to employ both the winter and spring sprayings. In this connection see the article on spraying, page 143.



Fig. 48. The Scurfy Scale.

The Scurfy Scale, *Chionaspis furfurus* Fitch, deserves notice here, although mentioned in the Twelfth Report. Both it and the previous scale appear to have become much more abundant since the printing of the last report in 1908. The Scurfy Scale gives to

trunks and branches of affected trees a "scurfy" appearance. The scale is oval, somewhat elongated, about one-tenth of an inch long, pointed at one end, and white. In addition to the apple, it affects pears where such are grown, also poplar, cottonwood, mountain ash, willow and other trees and shrubs. A closely-allied form is found on the elm. The life-history is much like that of the Oyster-shell Scale, and the same remedial measures are advocated.

The Buffalo Tree-hopper, *Ceresa bubalus*, Fab., is the cause of much complaint, reaching this division from nurserymen and orchardists. The illustration gives a fairly good idea of this queer-looking insect. We also insert figure of twig, showing the work of the female in laying her eggs. Fruit-growers frequently attribute these scars to hail. This work, of course, weakens the twig or branch. Further, any wounds made by insects of this class, or by tree-crickets, cicadas, or borers, must render the cane, shrub, or tree, as the case may be, more susceptible to attack of fungous or bacterial disease.

We believe egg-laying takes place in this latitude during the latter part of summer, the eggs hatching the following spring. Consequently, where judicious pruning can be resorted to, it is a good plan to go over the trees in winter or late fall, trim out the affected portions as far as can be done without deforming the tree, and burn the cuttings. Orchards and nurseries should be kept clean and free from weed growth. The usual accepted methods of spraying for insects and fungi are of some help in connection with this insect.

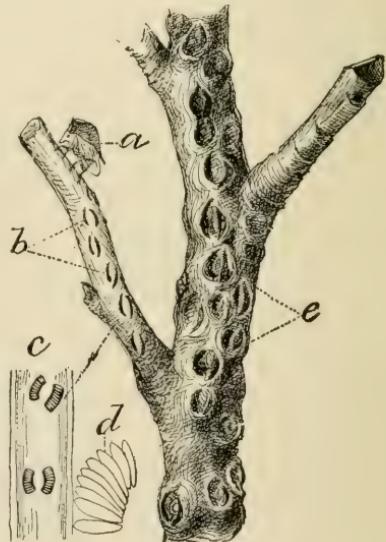


Fig. 49. The Buffalo Tree-hopper.
After Marlatt, Bureau of Entomology,
U. S. Dept. Agriculture.

THE STATE AND FEDERAL INSECTICIDE LAWS.

Two years ago Minnesota had no law governing the manufacture and sale of Paris green or arsenate of lead. In 1909 the Entomologist assisted in framing the following bill, which became a law through the action of the Legislature at its thirty-sixth session:

A BILL FOR AN ACT TO PREVENT DECEPTION IN THE SALE OF
"PARIS GREEN" AND OTHER INSECTICIDES.

Be it enacted by the Legislature of the State of Minnesota:

Sec. 1. Whoever shall expose for sale or sell within this state any "Paris green" or other insecticide which does not conform to all the requirements of this act, or which is labeled or marked in any manner so as to tend to deceive the purchaser as to its nature or composition, or which is not accurately labeled as hereinafter required, shall be guilty of a misdemeanor, and for each offense shall, upon conviction thereof, be punished by a fine of not less than twenty-five dollars, and not more than one hundred dollars, or by imprisonment in the county jail not exceeding sixty days.

Sec. 2. The term insecticide, as used in this act, shall include "Paris green" and any other substance or mixture of substances intended to be used for preventing, destroying, repelling or mitigating any and all insects which may infest vegetation.

Sec. 3. Any insecticide labeled, marked or called "Paris green", shall contain at least fifty per cent of arsenious oxide *in combination with copper*, not more of water-soluble arsenic than the equivalent of three and one half per cent arsenious oxide, and no substance that would injuriously affect its strength or quality. And any insecticide labeled and called lead arsenate or arsenate of lead must contain at least fifty per cent of actual lead arsenate, at least twelve and one-half per cent of arsenious oxide, and no added substances that would injuriously affect the quality or strength.

Sec. 4. The label required by this act shall clearly and distinctly state the name and residence of the manufacturer of the "Paris green" or other insecticide, or the distributor thereof, or of the party for whom the same is manufactured and show the name, and with substantial accuracy, the percentage of each ingredient, both solid and liquid, contained therein; said label shall be printed in the English language, in plain legible type.

Sec. 5. The having in possession by any person, firm or corporation dealing in said articles, any article or substance hereinbefore described and

not properly labeled, as provided in this act, shall be considered *prima facie* evidence that the same is kept by such person, or firm, in violation of the provisions of this act and punishable under it.

Sec. 6. The Dairy and Food Commissioner of the state is charged with the proper enforcement of all of the provisions of this act.

Sec. 7. The said Commissioner and his assistants, experts, chemists and agents shall be duly authorized for the purpose, and shall have access and ingress to all the places of business, factories, stores and buildings used for the manufacture or sale of such "Paris green" or other insecticide. They shall also have power and authority to open any package, can, or other receptacle containing such "Paris green" or other insecticide, that may be sold, manufactured or exposed for sale in violations of the provisions of this act.

Sec. 8. This act shall take effect and be in force from and after August 1st, 1909.

Congress has also created a law, in no way repealing or infringing on our state law, imposing severe penalties for the introduction into any state or territory, or into the District of Columbia, or from any foreign country, or for shipment to any foreign country of any insecticide or fungicide which is adulterated or misbranded within the meaning of the act.

Government officials are proving to be aggressive in punishing violators of United States law, and it is believed that this law will be of great service to fruit-growers.

Should any insecticide be manufactured and sold within our state borders, our state law will take care of it, and if any is imported into Minnesota, both the state and federal laws will insure protection to our fruit-growers in this connection. The penalties for infringement of the federal law are quite severe, and this law is noticeably more strict than the state law, in that it applies to any substance or mixture of substances intended for use against insects infesting "vegetation, man or other animals, or households, or which shall be present in any environment whatever," (the same latitude being given to fungicides) while the state law only applies to insecticides against insects affecting vegetation.

FOUR INJURIOUS SHADE TREE AND TIMBER PESTS.

Maple Borers, Elm Borer (*Saperda tridentata*), Birch-Leaf Skeletonizer, Box Elder Twig Borer, Larch Saw Fly.



Fig. 50. Elm tree dying from attacks of Elm Borer. Original.

The year 1910 has been an exceptionally bad one as regards borers and other pests on shade trees. Some of the finest elms in the Twin Cities have either died from the attacks of the Elm Borer, or have had their certain death anticipated by a free use of the axe in order to save other trees not yet attacked. The Elm Borer perforates the bark, loosening it from the underlying wood, and bores on the surface of the wood under the bark. This pest can easily

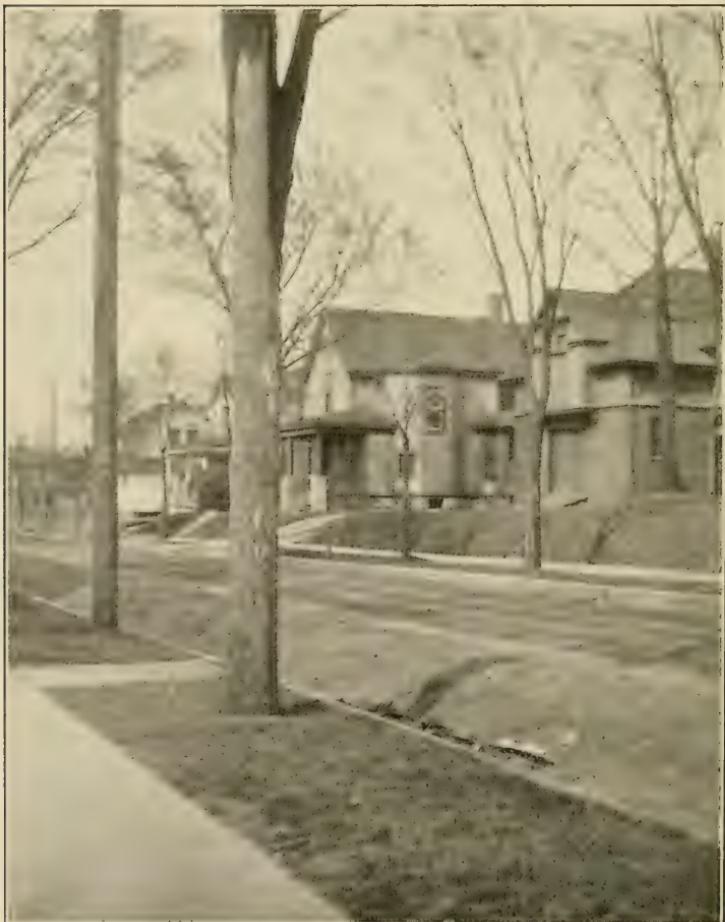


Fig. 51. Work of Elm Tree Borer. Tree in fore-ground killed. **Original.**

girdle a tree in this way, and hosts of elms in Minnesota have thus been killed. Frequently exudations, sometimes in the form of gum, and more or less of sawdust-like castings, will mark on the surface of the bark the opening of a burrow. This exuding matter from the burrow appears to attract ants; and we have sometimes detected the presence of this borer in an elm by first noticing the ants ascending its trunk. The deadly work of this insect begins to show itself in midsummer, though a tree-owner might not realize the fatal character of the attack until the following spring; when, perhaps, by the branches not leafing out properly, and by the generally diseased appearance of an affected tree, one realizes that something very serious is the matter. The branches die, sometimes even in the fall following the attack, and it is only a question of time—short at that—when the tree, which has taken so long to grow, succumbs to the work of an insect hardly more than an inch long. We found in Minneapolis, on April 20th, 1910, trees dying from the previous summer's attack, and containing at that date larvae of this beetle, of various ages, and pupae almost ready to emerge; indicating that the adult beetles would begin to emerge very shortly, possibly by May 1st or earlier, and continue to emerge during the summer, mating and laying their eggs on neighboring elms possibly not hitherto affected; dooming them, also, to a premature death. These facts are significant; for, when one finds trees evidently beyond cure, on account of the work of this borer, radical treatment is demanded. *Such trees should be cut down in winter or very early spring, and not piled up for firewood, thus allowing the beetles to mature and carry on their destructive work, but burned, trunk and branches at once, destroying all the beetles therein in whatever stage they may occur.* This should be done by park boards or other authorized officials, since individual owners are apt to neglect this important measure, thus allowing the pest to spread to the trees of their neighbors. Trees cut down in the late fall or early winter, might safely be used for firewood during that winter, but should be all burned before April 1st.

To protect trees not already attacked, or not severely injured, I would suggest several applications, beginning not later than May 1st, and repeating at intervals during the summer, of a compound composed of thick whitewash to which crude carbolic acid has been added at the rate of 1 quart of crude acid for every pailful of whitewash, and arsenate of lead, about six pounds for every fifty gallons of the wash. This wash could be colored with lampblack, making it grey and inconspicuous. It would, of course, brush off on the clothes of those touching the trees. This should be applied with a white-wash brush, over the trunk and the lower portions of the larger branches.

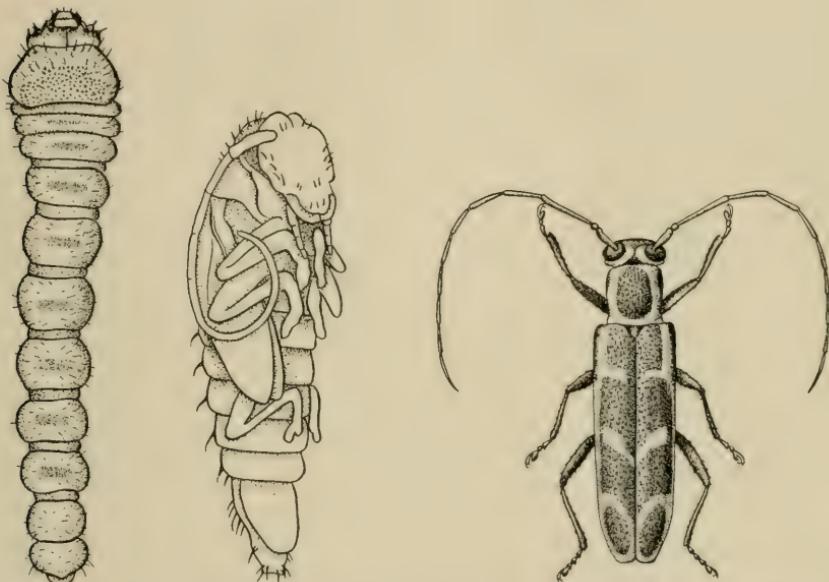
The larval borers, found in the burrows, are white and somewhat flattened. The beetles are brown, with a red stripe on the outer edge of each wing-cover, from which stripe three tooth-like projections of the same color project toward the center of the back.

We find in our notes a record of finding this pest as far back as November 6th, 1908, on which date we collected borers from the trunks of five trees on the corner of 27th Street and 1st Avenue, South, Minneapolis. They were most numerous close to the ground. In one tree they were numerous enough to have easily killed it. In 1909 injuries from this pest materially increased, and large numbers



Fig. 52. A near view of work of Elm Tree Borer. Original.

of trees in various parts of Minneapolis were found to be seriously infested. In some instances of infestation there were suggestions of injury by gas (bark peeled off around lower portions of trunks).



Figs. 53, 54, 55. The Elm Borer, *S. Tridentata*, larva, pupa, imago. Original.

and in the 1908 instance referred to there had been two leaks in a gas-main near the injured trees, and our assistant thought that the trees may have been injured by gas primarily, and that the borers came as a result of the gas injury. We have reared this same borer, *S. tridentata*, from Poplars.

Flat-headed Borers, all Buprestids—which may possibly prove, when reared, to be more than one genus—were extremely injurious to maples in 1910, and bid fair to become established as a prominent and destructive enemy of these valuable shade trees. Not having yet reared these larvae, we are not sure either of the genus or species, and hence, cannot speak with certainty of their life-history. It is probable, however, that they issue as adults in spring and summer. Such being the case, and from what observations we have been able to make to date, we would advise the cutting down in fall or winter or very early spring, of all trees which are evi-

dently doomed to die by these borers, and anointing the trunks and larger branches of trees in the neighborhood with some repellent wash, which is at the same time poisonous. The Minneapolis Park Board have been using a wash composed of whale-oil soap and arsenate of lead; the poison, of course, being for the purpose of killing any young larvae which may hatch and start to bore into the tree after the application. Further, if a tree is old, and the bark consequently rough, the old bark should be scraped off as far as practicable, so that the wash could be applied to the smooth bark below. As in the case of the elm-borer, maple trees cut down on account of the presence of borers should not be piled for firewood, but should be either used for fuel immediately or completely destroyed by fire. In order to secure prompt attention in this matter, since infested trees are a menace, the cutting down and destruction of such trees should be in the hands of some authorized official or officials, whose business it is to act quickly and intelligently in such cases.

The Birch Leaf Skeletonizer, *Bucculatrix canadensisella* has, in 1909 and 1910, proved itself a serious shade-tree pest, and we have received reports of its injuries from Duluth, Two Harbors, Northome, Margie and elsewhere. This insect, in its injurious larval stage, is a delicate, slender green caterpillar, with a brownish head. The green of its body may be inclined to yellowish. It is nearly or quite one-fourth of an inch in length when full grown, tapering slightly at anterior and posterior ends. It may lower itself from a leaf, when disturbed, by a silken thread. It spins a brownish or yellowish cocoon less than one-fourth of an inch in length, and attaches it to leaf or twig. From this cocoon emerges a brown moth not half an inch long, whose wings are crossed with delicate white bars. The larva feeds upon the softer parts of the leaves, and this leaves a brownish skeleton; in other words, it "skeletonizes" the leaves. The injury is conspicuous in the latter part of summer. Our notes show that all complaints of this insect were received in the month of September.

In a report from Duluth, of injury by the above insect, we found the leaf-roller, *Archips paralella* partially responsible; at least that insect was reared from material sent.

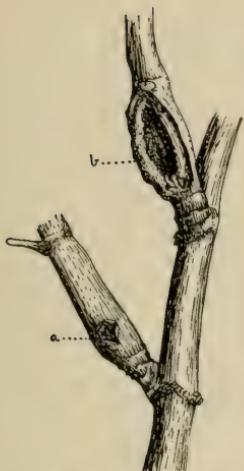


Fig. 56. Work of Box Elder Twig-borer. Original.

Where trees are not too large, spraying with arsenate of lead, four or five pounds in a hundred gallons of water, should be an easy means of controlling this pest. In cases of large trees, bamboo extensions handled from elevated platforms would enable one to place the spray higher than when working from the ground; or one could, in an emergency, climb quite a distance up large trees with stout branches, carrying the bamboo extension.

The Box Elder Twig Borer, is perhaps not, at this writing, a very serious pest, yet it is becoming extremely abundant. Our illustration gives a good idea of the appearance of the different stages of the insect, as well as the injury to box elders. The moth was identified for us, by W. D. Kearfott, as *Proteopteryx willingana*, described by him as a new species in 1904 (Canadian Ent., Vol. XXXVI, p. 306).

The collecting and burning of infested twigs in June and July would be a desirable way of lessening their numbers. This insect was discussed in the Twelfth Annual Report of the Minnesota State Entomologist, p. 97. At that time we had reared no males; and, from the females sent him, Dr. C. H. Fernald regarded it as *Proteoteras aesculanum* Riley. Specimens of males, however, were necessary to establish the exact identity of the insect.



Figs. 57 and 58. Larva and pupa of Box Elder Twig-borer. Original.

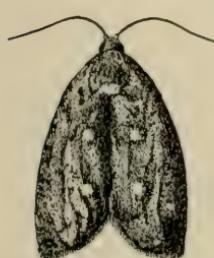


Fig. 59. Imago of Box Elder Twig-borer. Original.

The Larch Saw Fly, *Lygaeonematus ericksonii* Hart, is an enemy of our tamaracs which has caused considerable alarm amongst Minnesota lumbermen. We assigned the problem in its general and special aspects to Prof. Ruggles, of this division, who reports upon his 1909 and 1910 observations as follows:

The northern part of Minnesota has an enormous acreage in timber, and will have for a number of years to come, in spite of the forest fires and normal cutting processes. It has been impossible to determine the amount of tamarack in this region, although a number of foresters familiar with the tamarack areas have been questioned. An estimate given ran up into the millions of dollars.

When the Larch Sawfly began its depredations, in 1908, there was great concern among the lumbermen. The presence of this insect was first noted in August, 1909; though, from the dead and dying tamaracks seen, the pest must have been at work during the two or three preceding years. At the present time there are, to my knowledge, three areas of infestation in Minnesota—one at Itasca Park (a thirty-five-square-mile tract around Lake Itasca); one at Cloquet, where the State Forestry Experiment Station is located; and another near Ely, in the U. S. Government reserve. Unfortunately the writer has examined personally only the area at Itasca Park, Ruggles, and there not in the breeding season; but in each of two years, just as the larvae were leaving, or had, for the most part, left the trees.

The work on the insect has been done almost entirely in the insectary. Several hundred cocoons were gathered in the spring of 1910, but from this number only 125 adults were reared; and of these it is interesting to note that three were males, a larger percentage than Dr. Hewitt found in his work on the Larch Saw-fly in Europe; although perhaps, with a larger number reared, a smaller proportion of males might have appeared.

One species of *Hymenopterous* parasite was reared, which occurred in large numbers. I estimated that ten to fifteen per cent of the cocoons showed the presence of this parasite. Mr. C. T. Brues identified it as *Diglochus* sp.

Prof. R. H. Pettit, of East Lansing, Mich., learning that work was being done on this sawfly, kindly sent me a fungus preparation to scatter among the larvae as they were descending the trees to enter the soil. Unfortunately, this fungus arrived after the cocoons were well formed; but in spite of this a few experiments were started, and by September 1st the fungus had spread considerably. This fungus, however, seems to be almost identical with the one found by me this summer under natural conditions. In one small area I found as many as five per cent of the 1909 cocoons infested.



Fig. 60. Work of Larch Saw Fly.

The season of 1910, in Minnesota, was the dryest in the history of the white man. In Itasca Park where, in former years, the mosquitoes had been unbearable, in 1910 no mosquitoes were present, even in the usually swampy regions of the Park. I give this to show how dry it was. Now, whether because of this excessive dryness or not, the larch saw-fly larvae did not remain on the tamaracks as long as they had in previous years, leaving while the trees still showed green. Also, the cocoons were considerably smaller than they had been in previous years. It seems, then, that the tamaracks here will have a little respite next year from the gross attacks of these pests. The other regions of infestation, according to reports received, did not manifest any such peculiarity.



Fig. 61. Larva of
Larch Saw Fly. Ruggles.

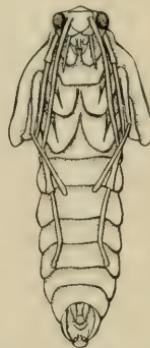


Fig. 62. Pupa of
Larch Saw Fly.
Ruggles.

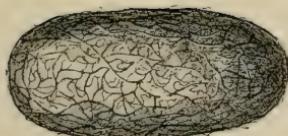


Fig. 63. Cocoon
of Larch Saw
Fly. Ruggles.



Fig. 64. Adult Male Saw Fly. Original.

The larva of this sawfly is, when full grown, a pale green worm, a little more than a half inch in length, and feeds upon the needles of the tamarack. The fly, or perfect insect, is half an inch long, with blackish body, marked by a band of red across the middle of the abdomen. It has four wings. This is the insect so well known for several years in the forests of the Middle West and New England. It is parasitized to some extent, and it is possible that we

will have to depend upon these parasites, or upon fungous diseases, in remote regions where large tracts are involved. They are not always troublesome, doubtless owing to the work of the two agencies just mentioned. If one has a few ornamental larch trees affected, the worms can easily be shaken off the tree; they will not climb up the trunk. Or the trees can be sprayed with arsenate of lead, four pounds to 100 gallons of water. This Division will probably have occasion to report further upon this timber pest at a later date.

A Cerambycid Beetle Infesting Black and Bur-Oaks.

On July 3d Dr. Franklin examined some bur-oak trees in Harriet Park, Minneapolis. Two large trees were in a dying condition, and two other very good specimens were already dead. In a borer-hole in the bark of one of these a beetle was found, which was pinned, and may be found by referring to accession reference, experiment 561. This was determined to be the Rustic Borer, *Xylotrechus colonus*. The presence of this beetle would seem to indicate that this was the species which caused the death and the dying condition of these trees. Several larvae were collected and bottled (see accession reference for experiment 561). Later, a large number of black oak trees in Minnehaha Park were found to be in a dying condition, and removal of the bark showed the work of a borer, which appeared exactly like that under the bark of the bur-oak trees in Harriet Park, above mentioned. So, while it is not certain, it seems probable that the Rustic Borer may have caused all this trouble.

It should be noted here that in other portions of Minneapolis, and also in St. Paul, oaks were seen during the season to be in poor condition, and a large number of them to be infested with borers. Whether many of them were infested with this insect is a question.

THE FRANKLIN CABINET FOR ALCOHOLIC MATERIALS.

As material preserved in alcohol or other liquid is often destroyed, or becomes much deteriorated by the liquids evaporating, it is desirable that vials containing materials so preserved should be kept in a place wherein the humidity is continuously at saturation point. When vials are left out, as they usually are, each having



Fig. 65. The case closed.

no particular place, they usually become dusty, and are difficult to keep in order. In view of these facts the cabinet described below was originated for the purpose of keeping alcoholic material clean,

in order and in condition. Details of this cabinet were designed by Dr. H. J. Franklin, hence we have given it his name.

The cabinet should be of galvanized iron. It has an inner and an outer door, with an air space between the two. The basal portion of the cabinet forms a pan or tray, which is air tight and contains a quantity of the same liquid as that which is in the vials.

The cabinet contains a number of galvanized iron trays, open at the top. These are divided crossways into spaces of different widths, according to the lengths of the vials to be placed in them. A small glass tube, exterior to the bottom of the case, acts as an indicator to show, without opening the case, how much liquid the cabinet

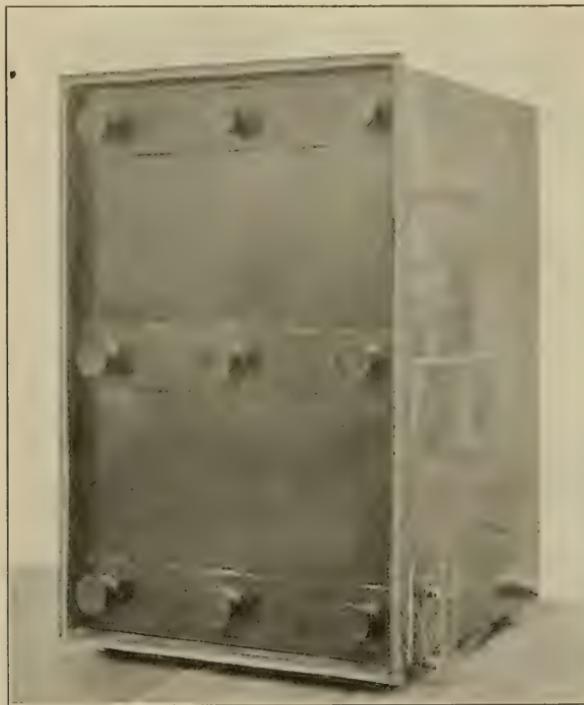


Fig. 66. Case with outer door removed.

contains. This glass tube is provided with a stout wire guard. Our case, with the exception of the shelves, was made of tin throughout; and the bottom of it, where the liquid was kept, rusted badly in time. If it had been made of galvanized iron, this would have been prevented. Our case was made according to the following measurements:

The case proper is $28\frac{1}{2}$ inches from top to bottom, 20 inches from front to back, and $18\frac{3}{4}$ inches wide. It rests on five tin feet. The inner door consists of a plate of tin, around the margin of which, on the inside, there rests a V-shaped ridge, which fits into a gutter of the same form. The gutter is lined with heavy felt. On the outside of this inner door there occur at regular intervals nine tin buffers, ranged in three rows. These buffers are in the form of truncated cones, the bases of the cones constituting the outer portions of the buffers. The outer door is one and one-half inches

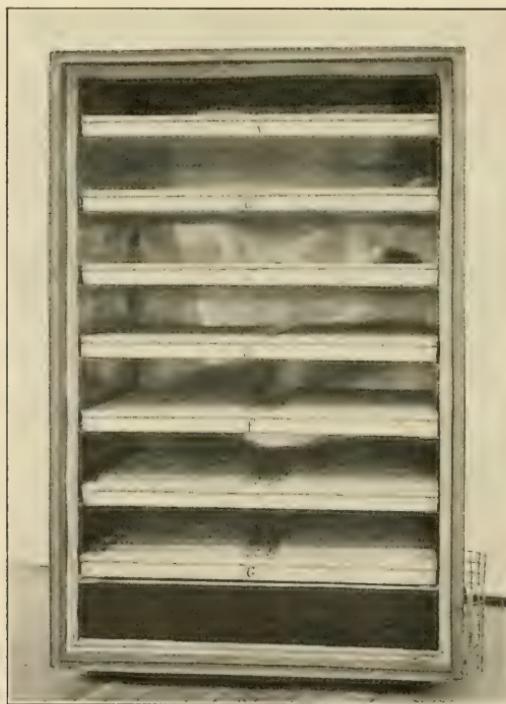


Fig. 67. The case with both doors removed to show trays for holding vials.

from the inner one. It has upon its internal margin a square ridge, which fits into a square gutter exterior to the wall of the case. This gutter is also lined with heavy felt. The outer door is fastened in place by six clasps—one at the top and bottom, and two at each side. They clasp around the base of the outer gutter. This outer door presses snugly against the buffers on the outside of the inner door; so that, when the outer door is firmly clasped in place, the inner

door is kept also in place by the pressing of the outer door against these buffers.

There are seven trays, each of which slides, after the manner of a drawer, on a small tin shelf on each side of the interior of the cabinet. The shelves are $1\frac{1}{2}$ inches wide. The tubular indicator is 3 inches long, and consists of a bent glass tube, the top of which enters the case just below the shelf of the lowermost drawer, and the bottom of which enters flush with the bottom of the reservoir for liquid. The connections for the indicator are made with plaster of Paris. The wires of the protecting screen are soldered to the side of the case. The drawers are $16\frac{3}{4}$ inches wide, 18 inches from front to rear, and 1 inch deep. The apartments vary in width ac-



Fig. 68. Details of trays of Franklin vial case.

cording to the lengths of the vials to be placed in them. Down the center of each drawer, running from front to back, on top, is a horizontal strip of galvanized iron, which holds in place the top of each partition. This strip is $1\frac{1}{2}$ inches wide. The seven drawers are lettered in front from A to G, and the numbers on the partitions of each drawer run along the horizontal strip which runs across them above. This numbering and lettering is for the purpose of making it possible to "accession" the material and keep it in known order.

METHOD OF REARING BORERS.

As it became desirable to rear borers from white birch, a means was devised for doing so by Dr. Franklin, at that time in charge of the Insectary; and it proved so satisfactory that it seems worth while to describe it. This method has served not only the purpose of rearing these borers, to find out what they are, but it has proved to be so effective that it has value in rearing all borers when present in large numbers; and probably, by means of this method, a practically complete emergence can be obtained, thus giving a good idea of the amount of infestation in all cases in which this method is used.

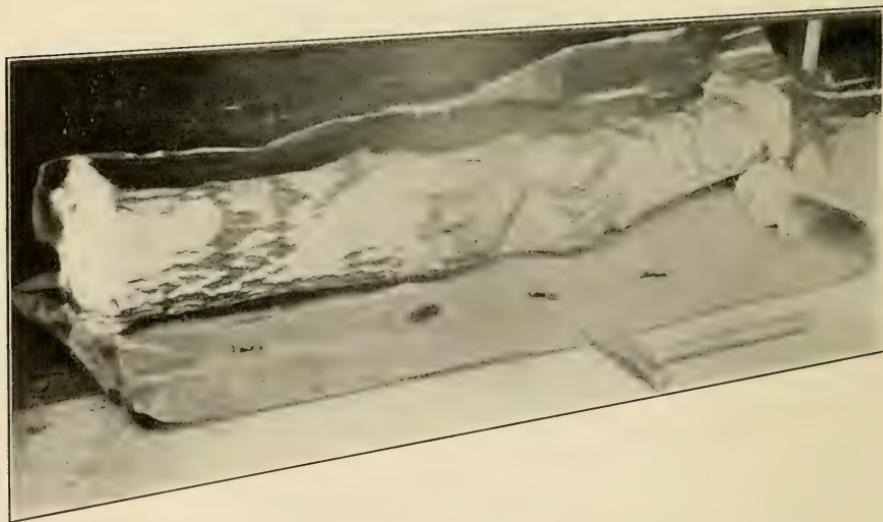


Fig. 69. A device for rearing borers from a log of considerable size. Inclosing the log. Franklin.

A portion of a cut-leaf birch log, badly infested with larvae of the Bronze Birch Borer, *Agrilus anxius*, seven and one-half inches in diameter at one end, and six inches at the other, and four feet two and one-half inches long, was carefully and loosely wrapped

in copper wire cloth, No. 60 mesh, so that only very minute insects could get through it. Along one side of the wire cloth were cut five small openings, the edges of which were deeply jagged. The individual scallops or jags in each opening were turned backward over a ring of cork, of such size that it would fit tightly into the base of a lamp-chimney; then this jointure or junction was reinforced with putty, which was tied in place with cloth bands until it got hardened. The outer ends of the lamp-chimneys, which made this close connection with the interior of the wire cloth case, were closed with removable tin box caps. The wire cloth was nailed down to the log, along one side and at the ends, with small staples; and the connection between the two ends of the cloth, so caught



Fig. 70. A four-foot two-inch log covered with wire gauze and chimneys in place. Franklin.

together along the side of the log, was made tight with putty. Small pieces of cork were nailed to the side of the log underneath this putty line, so that beetles which might emerge would have free chance to move all over the log, excepting around the ends, where they were shut off by cotton stuffed inside of the cloth and around the ends of the log. After everything was made tight in this way—the lamp-chimneys being in place, and their ends being held up from the ground in a horizontal position by cross-sticks placed under them—the whole cage was covered with coarse sacking and paper, and then this sacking and paper was covered with sand, leaving only the lamp-chimneys protruding. In this location the

log was provided with the natural dampness of the earth to a large degree, and at the same time the sand gave admission to enough air, so that everything was kept in good condition through the winter. This apparatus was kept in the outer cold portion of the insectary.

It will be seen that this cage was intended to work on the same principle as the parasite-cages already so generally in use—that is, the lamp-chimneys take the place of the glass tubes in the parasite-cage—and it was taken for granted that the beetles, when they emerged, would go to the light in the lamp-chimneys.



Fig. 71. The "borer cage" ready to be covered with sand. Franklin.

The log passed the winter in good condition, and the adult beetles emerged regularly from July 1st to July 8th, and were all in splendid condition, twenty-six in all being taken from the chimneys. The log was afterward chopped open, and no dead larvae or pupae were found in the experiment. The adults which were taken from the experiment were all pinned, and many larvae of this species were bottled, and these specimens may be found by looking up the accession references of experiment 410, 1908.

A general view drawing of this apparatus was made as it lay in working condition in the sand, and also a drawing of one of the lamp-chimneys, showing the connection between the lamp-chimney

and the wire cloth. Five photographs were made of this apparatus —one showing the apparatus in working condition in the ground; one with the dirt removed, showing the apparatus in place, with the wire cloth covered with paper and burlap; and one the same as the second with the paper and burlap removed, showing just the wire cloth enclosing the log, which, in the photo, shows through the wire cloth, and the lamp-chimneys in place; one showing the connections between a lamp-chimney and the wire cloth, the outer portion of the chimney having been broken off; and the fifth showing the interior view of the wire cloth, it having been detached from the log and opened out, showing the log lying inside of the wire cloth, with the cotton lying round its ends.

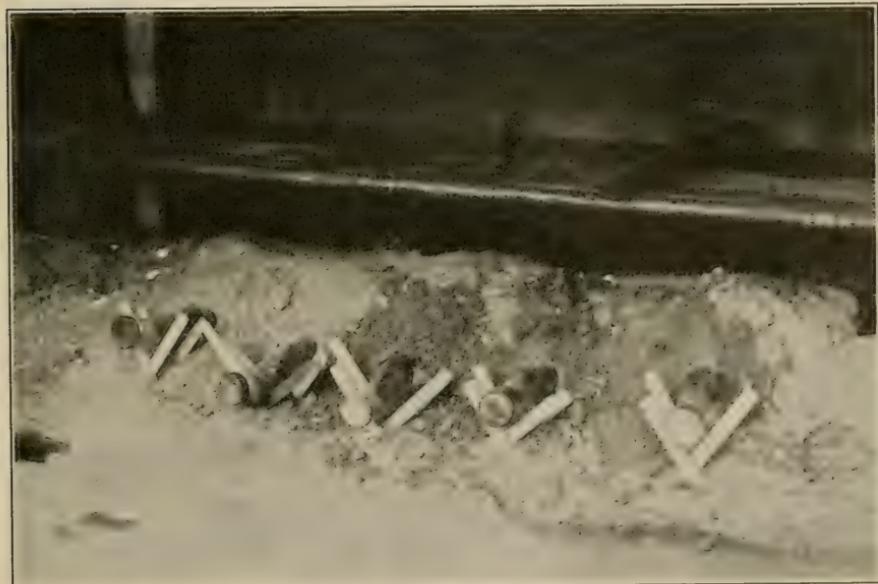


Fig. 72. Covered with sand in cold room of insectary. Franklin.

"MINNESOTA INSECT LIFE."

This publication, edited by the State Entomologist, is issued upon the first of April, May, June, July and August of each year. Its object is to place before farmers, nurserymen, fruit-growers, gardeners and housekeepers, timely items, which will be of value in suggesting methods of preserving their property from the attacks of insects. The first issue was June 1st, 1910, and hence there were but three numbers in that year. Next year (1911) there will be five numbers, beginning April 1st.

The name and address of any citizen of Minnesota, wishing copies of Minnesota Insect Life, will, upon request made to the State Entomologist, be placed upon our mailing-list, and copies will be mailed free of charge as soon as published. The contents of the 1910 issues, listed below, will give an idea of the nature and scope of the publication; which, by the way, is in no sense a bulletin, but merely intended to get certain facts before the public quickly, when most needed.

JUNE: Cutworms, Striped Cucumber Beetle and True Squash Bug; Oyster-shell Scale and Scurfy and Scale; House Fly; Strawberry Weevil; Spraying Compounds and Spraying; Green Cabbage Worm; Grasshoppers; Bee Pasturage; Stalk Borers in Flower-Gardens; Plant-Lice or Aphids; Item of Interest.

JULY: More about Grasshoppers; On the Successful Raising of Asters; The White Grub in Lawns; Mites and Lice of Chickens; Tent and Forest Caterpillars; The Cabbage Maggot; Jiggers; Items of Interest.

AUGUST: The Grasshopper Situation; The Army Worm; Black Flies and Mosquitoes; Ants in House and Garden; Spraying and Spraying Machinery; Cockroaches; The House or Typhoid Fly.

THE MINNESOTA INSECT CHARTS.

The Legislature of 1908 provided a fund of \$3,500 for the preparation and distribution of a colored chart to the public schools of this state, under the direction of the State Entomologist. These were completed and distributed in the spring and summer of 1910; requests for them still reaching us. The chart is upon heavy, glazed paper, about 2 feet $10\frac{1}{2}$ inches by 3 feet 9 inches, mounted with metal rods above and below, and contains about sixty-four colored figures, illustrating in natural colors many of our common (and some uncommon) insects, a few useful birds, and some beneficial insects. Drawings were made either from museum or from living specimens, by Miss Wood, artist of the Division, who also did all the color-work. The engravers and printers have attained fine results, remarkably true to copy, and the finished chart is an excellent example of what can be done with good brush work, the four-color process, and accurate and careful process work. The charts are fine enough to have called forth expressions of admiration and congratulations, not only from teachers and others in Minnesota, but also from many sources throughout the United States, the engraving company having sent samples of this work to many state institutions.

Following the suggestion of Prof. Schulz, State Superintendent of Public Instruction, letters were sent to all county superintendents, requesting them to advise us as to how many charts were needed in their counties. The required numbers were then sent by express, and were distributed by the superintendents, many of whom gave explicit instructions to their teachers as to the proper care and use of the chart. The following short circular, published by Prof. Frederickson, and sent with the charts to his teachers, is well worth being made use of in other counties:

Rules for Keeping and Using the Insect Charts.

This insect Chart is the property of the school district. It should be well taken care of. When not in use it should be rolled up so the dust and light will not dim the colors. I will suggest that a piece of oil-cloth, a little longer than the width of the Chart and about ten inches wide, be hung back of the Chart, so that when it is rolled up the oil-cloth can be wrapped around it.

The purpose of this Chart is to serve as a basis for teaching the pupils what insects are injurious to field and garden, and what can be done to exterminate them or lessen their number. Will suggest to the teachers that the study of one insect be taken up at a time, and give its life-history, its habits, what plants it feeds on and what may be done to destroy it.

Teach the pupils what birds are beneficial and should not be destroyed.

Lessons of this kind could be given once or twice a week.

It is hoped the teachers will not regard this Chart simply as a curiosity, but use it as it was intended.

W. D. FREDERICKSON,
Co. Supt. of Schools.

The accompanying half-tone gives an approximately correct idea of the appearance of this chart, barring the lack of color. In addition to the brief description under each figure, we mail a pamphlet with additional information.

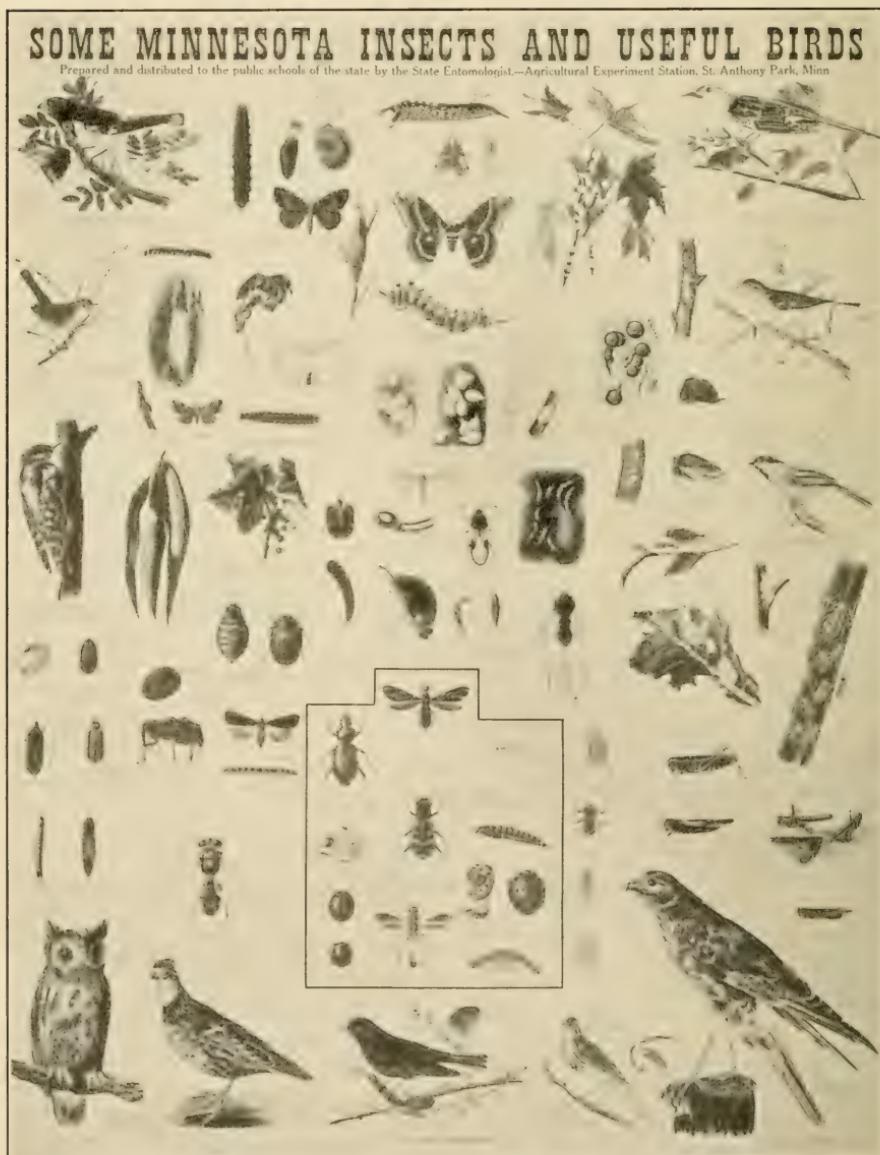


Fig. 721½. The insect chart distributed to the public schools of the State.
Much reduced.

NOTES ON WORK OF INSECTARY AND EXPERIMENTAL GARDEN.

In 1909 three hundred and fourteen different experiments were carried on in the insectary. Two hundred and fourteen insectary experiments is the record for 1910, which really represent a much larger number, included as "sub-experiments." A large number of insects, sent in to us for identification, were reared to maturity, as well as much parasitic material.



Fig. 73. A simple device used as breeding cage. Urbahns.

A parasite breeding-cage, built by Mr. Urbahns, and found quite satisfactory, is shown in Fig. 77. Cheese-cloth forms the upper half of the back and entire end of each set of cages, the partitions between the individual cages being of board. The front, as

indicated, is made of panes of glass, which slip into grooves, strips of felt making these glass doors (for such they are) tight. Fig. 73 shows a practical form of breeding-cage, also made use of by Mr. Urbahns; namely, large flower-pots under which any host material, other than a growing plant, can be placed. Upon the inverted flower-pots are placed glass chimneys, as indicated, into which ascend insects emerging and seeking the light. A board base, containing ventilators covered with fine copper gauze, may be used where collections of green materials are inserted.

In the experimental garden much work was done, in 1909, against stalk-borers, see page 85, and in both 1909 and 1910, various vegetables were planted for experimentation. The garden contained, in 1910, peas, beets, carrots, tomatoes, tobacco, corn, potatoes, cucumbers, clover, alfalfa, wheat, melons, sorghum, flax, beans, plum and apple trees.

The object of this garden was:

1. To have all these plants on hand as they were needed for insects in experimental work.
2. To carry on preliminary experiments in combating insects attacking these different crops.
3. To keep in touch with the different pests attacking each crop.

Sorghum was planted for the sole purpose of trying to see if *Contarinia sorghicola* would attack the seed. Melons were planted to watch *Aphis gossippi*, with hopes of getting notes on egg-laying habits. On potatoes, notes were taken on preliminary sprayings.

A few experiments were tried with insecticides, notably against the potato beetle, with both Paris green and arsenate of lead. This work was carried on by Mr. Stafford. We are hardly justified in forming absolute conclusions from the following results:

1. Potatoes sprayed with arsenate of lead, 1 pound to 50 gallons. Results: Considerable reduction in number of larvae.
2. Potatoes sprayed with arsenate of lead, 2 pounds to 50 gallons. Very few living larvae present.
3. Potatoes sprayed with arsenate of lead, 4 pounds to 50 gallons. Results: About the same as in two preceding experiments.
4. Potatoes sprayed with Paris green, 1 pound to 50 gallons. Results: "But little improvement. Many living larvae."
5. Potatoes sprayed with Paris green, 2 pounds to 50 gallons. Very few potato beetles alive.

6. Potatoes sprayed with Paris green, 3 pounds to 50 gallons. Same results as No. 5.
7. Potatoes sprayed when dry with Paris green 1 ounce, flour 20 ounces. Killed the beetles and larvae.

Comparative experiments were carried on also, by Mr. Urbahns, with arsenate of lead and Paris green. Good results were secured with arsenate of lead, 3 pounds to 25 gallons of water; and also with Paris green, 1 pound to 25 gallons of water. The comparative results were slightly in favor of the Paris green spray.

A poisoned bran-mash was used with success against cut-worms. To two pecks of dry bran, enough Parish green was added to impart a *decidedly green color* to the mass. Then enough water was added to make it of the consistency of chicken dough. Then enough black molasses was added to sweeten it and give it a decided odor. Any syrup might have done as well, possibly. This poisoned dough was scattered about in small masses amongst the plants in the experimental garden.

Preliminary Work with White Grubs.

Lachnostenra adults, removed from sod in insectary, garden on May 29th, and placed in a breeding-cage under out-of-door temperatures, were first active on April 11th. Fed freely on plum-leaves. Three hundred and fifty of these adults were placed in cages containing soil. They were active on warm nights between April 11th and June 1st. Thirty adults of *Lachnostenra*, remaining alive on June 1st, produced 106 eggs. See Fig. 73½.



Fig. 73½. Eggs of White Grub Beetle *Lachnostenra*. Urbahns.

May 5th, thirty adults captured in a lantern trap—most of them died. Thirty-five eggs had been deposited in the soil June 1st. These came from those of the captured beetles which survived after being placed in breeding-cage.

June 10, twenty-six adults taken in lantern-trap during night. Some of these were observed mating.

June 11, fifty-three adults taken in lantern-trap. These deposited a few eggs.

**A Successful Method of Securing
the Fertilization of Clover by
Means of Bumble Bees, in Ex-
periments with *Bruchophagus*
funebris.**

At the very beginning of work on the life-history of *Bruchophagus*, we found it necessary to secure clover-seed properly fertilized, and yet immune from insect attack. This, as we discovered, was a most difficult thing to accomplish. For two years we tried in vain to do this by hand-pollination, the work being begun by Mr. Ruggles and continued by Dr. Franklin. Naturally we were discouraged. I am happy to say, however, that this year, by the method described here, we have succeeded in this very essential principle, and have had no trouble in securing fertilized seed, suffering in no way from insect attack, and thus forming a basis for investigations on the life-history of the insect in question. As stated above, the work was begun over two years ago by Mr. Ruggles, later joined by Dr. Franklin. We have recently added to our force, under the provisions of the Adams Act, Mr. Theodore Urbahns, who is at present giving his entire time to this problem. Mr. Urbahns has invented a simple cage, which seems to answer the purpose for which it was intended excellently well. This cage is made with

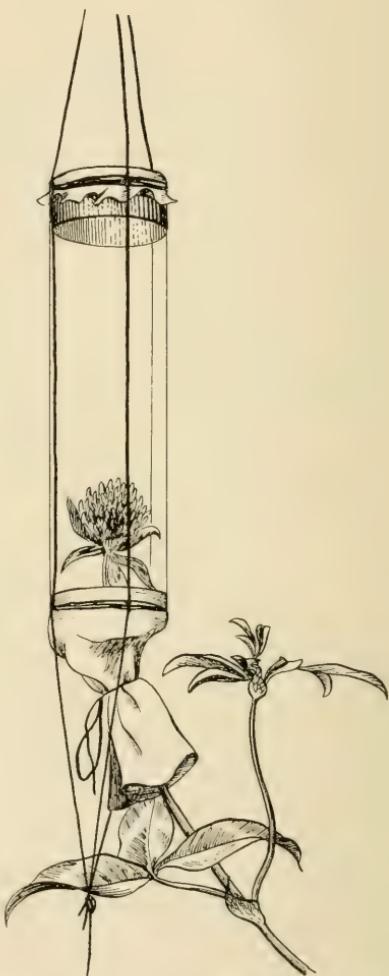


Fig. 74. A mica lamp chimney showing method of inclosing cloverhead Urbahns.

a wooden frame, covered with white cheese-cloth on three sides and on the top. A loose glass plate forms the fourth side. The floor is of wood, perforated in the center in such a way as to allow cloverheads from two or more plants to be introduced into the cage. The apparatus is suspended over the growing plants. The perforations through which the clover-heads are introduced can be shut to exclude other insects, and to keep the clover-stems in place, by means of two wooden shutters.

The method of procedure in securing the cross-pollination of the florets has been to confine the green heads in other cages, made of mica lamp-chimneys, closed at the top with a piece of cheese-cloth and at the bottom with a fold of the same kind of cloth, which can be firmly tied around the stem bearing the introduced head. This cage is held in place above a plant by a cord from above and below. The latter apparatus was suggested in an article by C. E. Hood in the April, 1909, number of the *Journal of Economic Entomology*. Of course these heads might have been covered with cheese-cloth bags, but in that case they could not have been so easily watched. When

the florets open and are ready for pollination, they are removed from the mica cages and introduced into the cage made by Mr. Urbahns, and described above. Into this cage one or two bumblebees are introduced, and we found that early in the season the bees worked faithfully every day, after becoming accustomed to their prison, occasionally for as long as three weeks. Later in the season their work was not quite so satisfactory, but when captured early in the morning they usually worked well for a few hours, after which time they were liberated. When these clover-blossoms have been thoroughly gone over by the bees, they are removed from the pollinating cage, and again placed in the mica cages for future

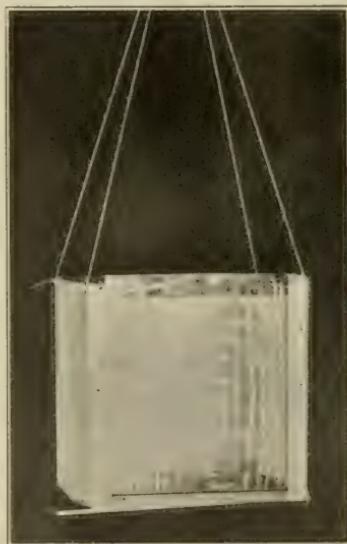


Fig. 75. A simple and successful breeding cage. Urbahns.

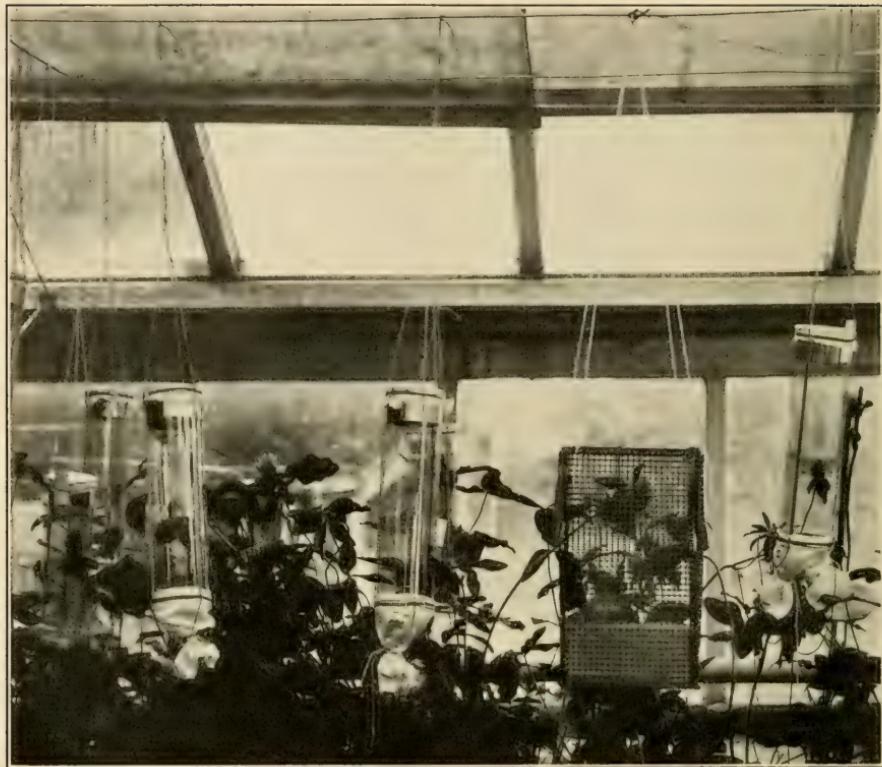


Fig. 76. Lamp chimneys in use. On the right a cage first used with Bumble Bees.

use in *Bruchophagus* studies. In the photograph, the white lines across the front are chalk lines made to warn the imprisoned insect and prevent its flying against the glass.



Fig. 77. Two tiers of parasite breeding cages. Urbahns.

A Jumping Seed-gall on Oak Trees.

Mr. C. N. Ruedlinger, Forester of the Minneapolis Parks, brought in on July 3d, 1909, some leaves of bur-oak, which bore on their undersides large numbers of little round galls. These galls contained the larvae of small insect, apparently Cynipid or Chalcid, and a rustling sound could be heard across an ordinary-sized room because of the movement of the larvae inside the galls. Mr. Ruedlinger also brought a large number of the galls which he had collected from the ground, these having become detached from the leaves of the trees and fallen down in large numbers. In their detached condition the insects had the power of making the galls which surrounded them hop several inches from one place to another. When on the trees, there occurred from a few to several hundred of these galls on a single leaf. They seldom were found toward the basal portions of the blade of the leaf, but were scattered over the rest of the leaf. These "jumping seeds" as the public called them, excited much interest.

Corresponding with the positions of the galls on the lower side of the leaves, there were convexities on the upper surface. These galls, while round, were flattened somewhat, that is, depressed.

Some of the galls were opened at the time they were brought in, and the insects inside were found to be in the pupal stage. When the galls reached the stage at which they detached themselves from the leaves they were a very light chrome yellow color, and about 2 mm. in diameter. These were placed in lamp-chimneys, the ends of which were covered with muslin, and were placed on the ground both inside and outside of the insectary. In this way they could be kept and given the natural moisture of the earth. The galls continued to show their hopping movements with considerable vigor as late as August 4th, and a slight hopping was noticeable as late as August 21st.

A large number of insects, mostly Chalcids, emerged in these experiments from July 1st to August 2d. These were apparently parasites on the real gall-formers, as but a small percentage of the galls show that insects had emerged from them, and the hopping continued for a considerable number of days after these insects ceased to emerge.

These parasites were all mounted in balsam on slides, and some of the leaves bearing the galls were pressed and put up in Riker Mounts, and a large number of the galls were bottled in alcohol and formalin.

On September 17th these insects were all placed under a wire cage out of doors to be carried through the winter, but no adults have emerged up to the date (Dec. 1, 1910) of making this report. From descriptions, however, of the gall of *Neuroterus saltatorius* and a careful examination of this gall we believe that to be the species in question.



Fig. 78. Jumping Seed Galls. Upper and lower views of leaf and details. Original.

Work with the Box Elder Borer.

Moths of this insect were sent to Prof. Fernald for determination some time during the summer of 1908. Prof. Fernald was unable at that time to give a definite determination because he lacked the males, that sex possessing the more distinctive characters. From the females sent him, he judged it to be *Proteoteras aesculanum*, Riley.

After this further experiments were carried on to get more insects for determination, and to learn more about the life-history of the insect. First an experiment was conducted to secure the egg-laying of the moths and find out the length of larval life. Adults were placed in a breeding cage on box-elder seedlings. Some time after the moths had disappeared this experiment was examined, and large numbers of small larvae were found feeding next to the midribs of the leaves of the tree, and some were crawling up and down the stem of the plant. These larvae finally, after feeding on the leaves for a considerable length of time, as cooler weather came on during the latter part of August, stopped feeding on the leaves, which they had at this time pretty well skeletonized, and bored into the tips of the twigs. They remained in this position for some months, but the plant finally died and the insects also perished. A few small larvae were saved and kept in small branches of box elder, which were kept moist all winter, but these, too, finally died, so that a complete cycle of the life-history was not obtained, but it is evident that the small larvae pass the winter in twigs of box elder, and in the spring proceed with their development until they become full grown.

On June 23d and again on July 14th, a large number of these borers were collected from box elder, for rearing to get the moths. By July 14th a large part of the borers gathered on June 23d had pupated, and from this time on the remaining larvae went into the pupal stage rapidly. On July 14th the first moth in captivity emerged. The last moth of which we have record, emerged on

August 4th. Nineteen moths in all were reared. With this material at his disposal.

There is bottled material showing the work of this insect, and for that matter branches showing its work could at any time be collected. At all events, if this insect is written up, it would be desirable to have a photograph showing its work. Some of the borers were bottled, and some were also inflated. All the pinned and bottled material connected with this borer may be found by referring to accession references of experiments 544, 588 and 590. In experiments 588 and 590 parasites emerged and were pinned.

Mr. W. D. Kearfott identified this insect as *Proteopteryx willingana*, which is described by him in the Canadian Entomologist Vol. XXXVI, page 306. The late Dr. Fletcher refers to it (Report of 1904) as "The Negundo Twig Borer," and states that it has become quite a pest in Canada to trees of that genus, though not a serious one. It occupies about the same position in Minnesota. Manifestly the burning of infested twigs which contained insects would afford relief during the latter part of June and during July would be a desirable way to lessen their numbers.

THE TYPHOID FLY ON THE MINNESOTA IRON RANGE.

Your entomologist was called upon in September, 1910, by a member of the State Board of Health, to visit with him some of the towns of the Iron Range, for the purpose of determining to what an extent the house fly or typhoid fly was responsible for an epidemic of typhoid fever then prevalent there.

During the first trip, and on the occasion of a second trip made later, we found the following conditions: House flies were extremely abundant, and houses of miners, boarding houses, cheap hotels, camps, etc., were improperly screened. The surroundings of some of the dairies in that section were in the highest degree unsanitary. Revolting conditions, in large part the result of ignorance or indifference, or both, on the part of the miners, were prevalent in every place visited. The miners consist largely of Austrians, Italians, Finns, and a very few Swedes. Although the Finns and Swedes are by far more cleanly in habits and environment than the other two races, they were the chief sufferers from typhoid, due to the fact, we believe, that both Finns and Swedes lunch frequently during the day upon cold food. The Italians eat hot meals, as do also the Austrians, and the former use but little milk. These two races, although much to be criticised along the lines of cleanliness, escaped typhoid. The cold food referred to above is on the table all day, freely visited and walked over by flies which enter through unscreened windows or doors, having come directly from near-by filth; in some cases undoubtedly from typhoid excreta deposited in open vaults without having been sterilized. In more than one case we found a landlady temporarily caring for a typhoid boarder before he went to one of the hospitals, if indeed he were fortunate enough to get into a hospital, and at the same time cooking for her remaining guests. A dangerous combination, especially with the prevailing ignorance as regards the germs of the disease.

We found that the sewer of one of the towns, a city of about 12,000 inhabitants, emptied into an open creek less than a mile away,

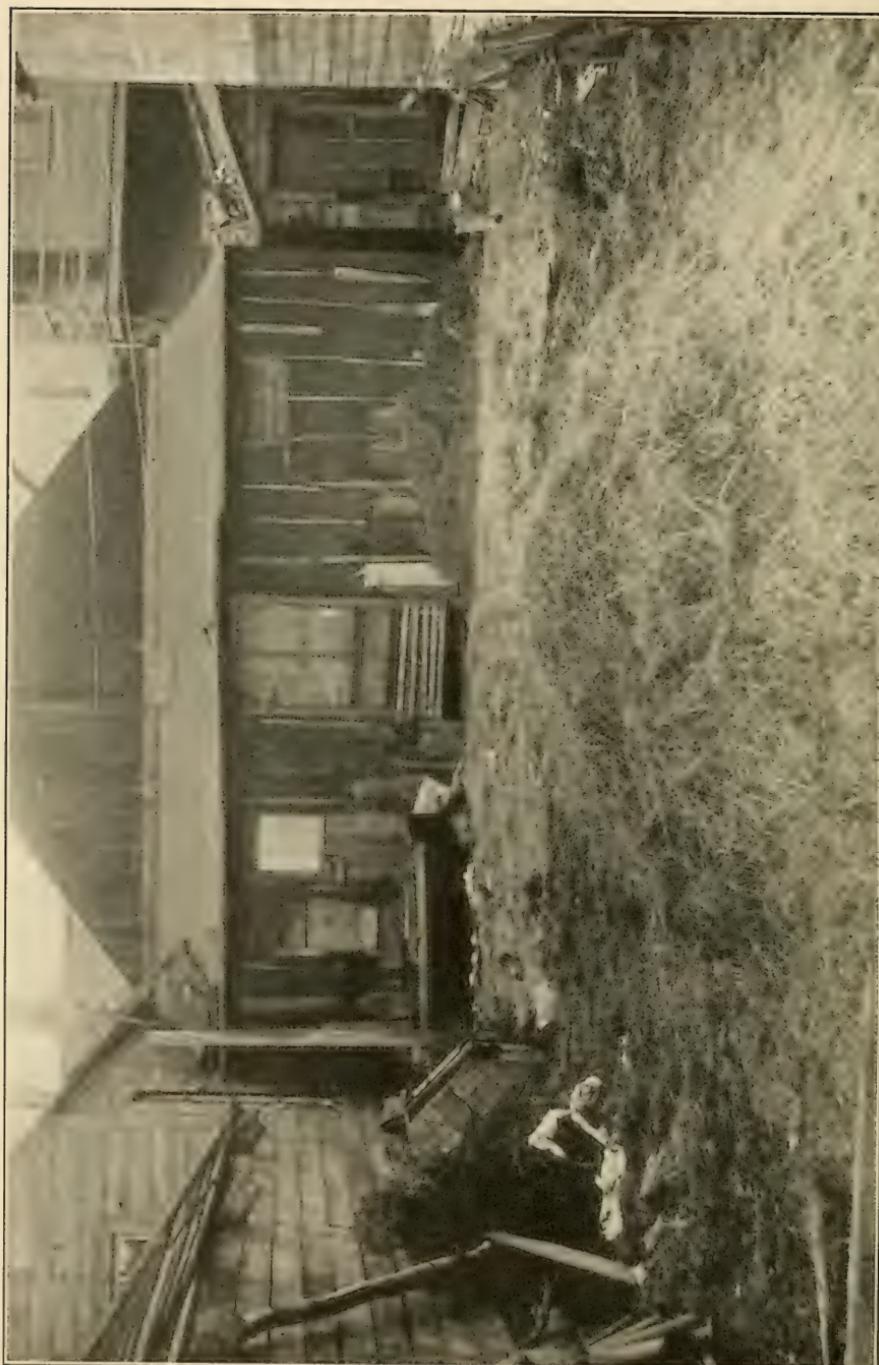


Fig. 79. Conditions in the rear of a city restaurant, taken from the adjoining alley.

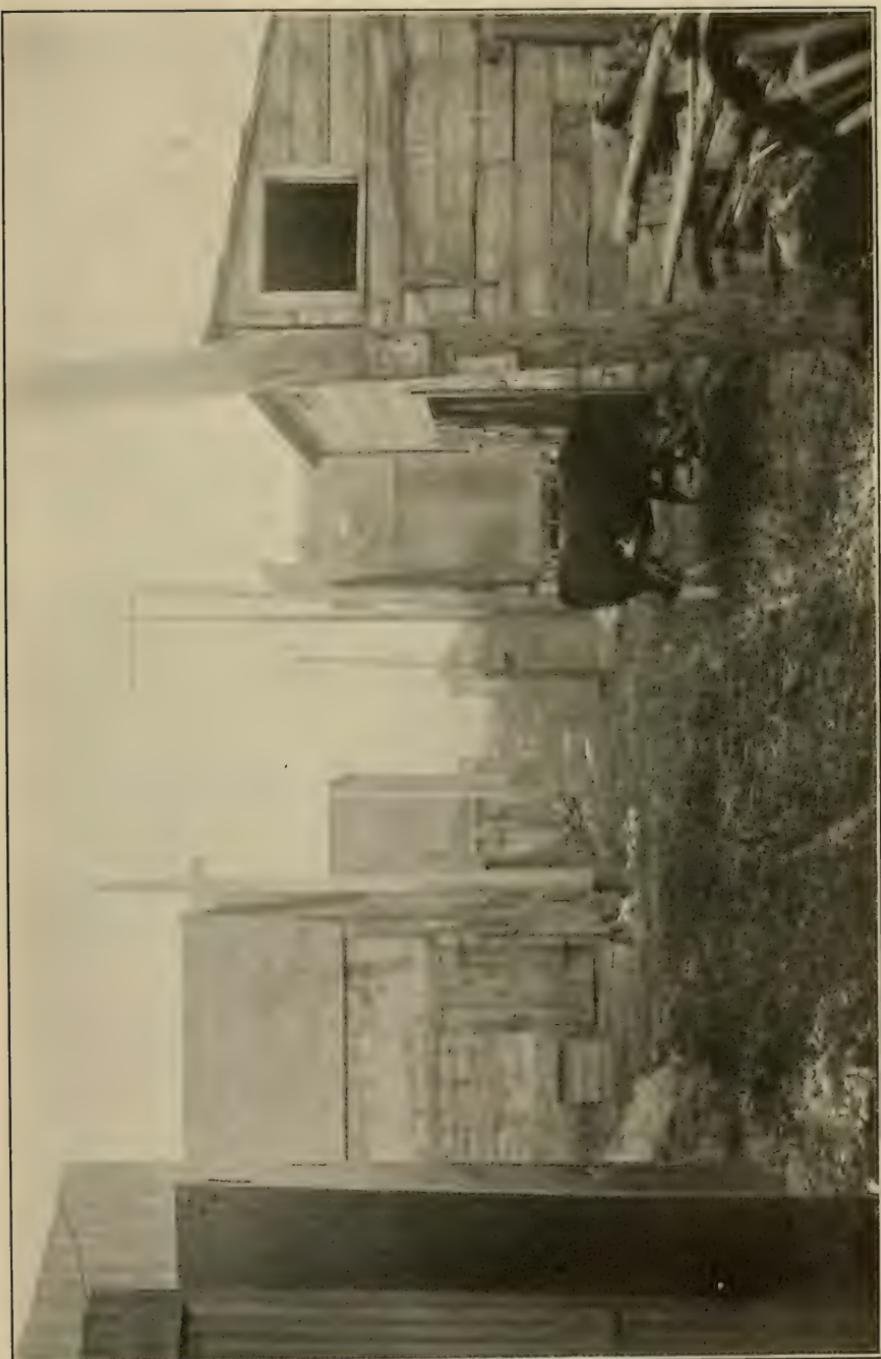


Fig. 80. Alley near Main street of one of the Range towns.

and that flies of various kinds congregated there upon the filth floating in the slow-moving stream. Delivery wagons cross this creek in their trips to and from neighboring towns and "locations" many times a day, and we personally observed that flies were carried from the creek upon vehicles of this sort, offering, with the unscreened houses everywhere met with, ideal conditions for the spread of the epidemic. To add to the difficulties which local au-



Fig. 81. Another filthy alley.

thorities have to contend with is the fact that Finns, Austrians, and Italians are more or less fatalistic in their views; and furthermore, they are somewhat suspicious of would-be well-doers connected with the mining companies or cities; they are loath to use the medicine given them (especially true of the Swedes), and evidently have not been used to such attention in the old country. It

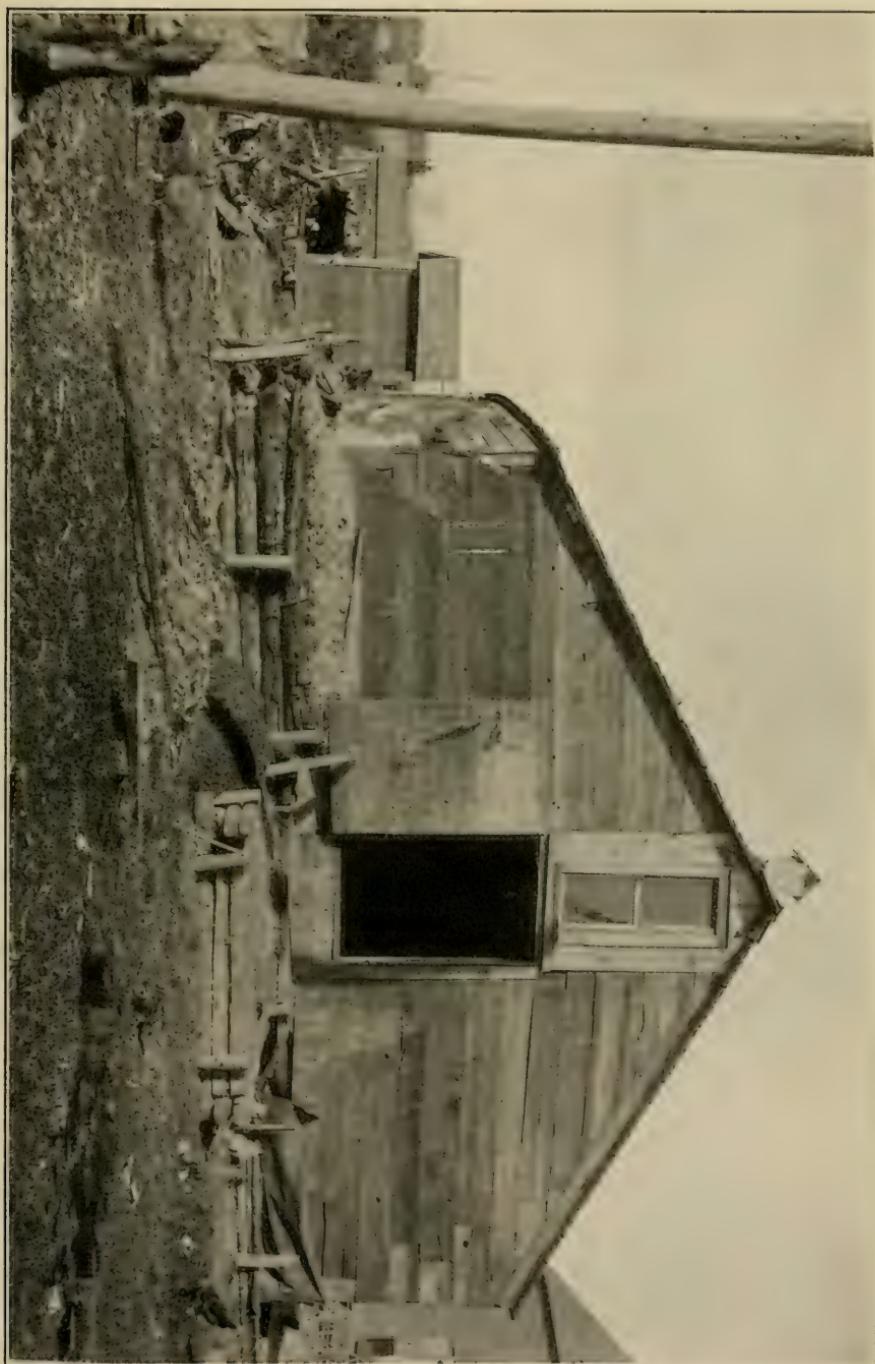


FIG. 82. An unsanitary dairy. A large pile of manure was removed from in front of the above the day before this photograph was taken.

must be borne in mind, also, that these foreigners have brought with them from their own countries all their habits; their temperament is unchanged; they surround themselves here with the same conditions, as far as they can, which they found congenial there—all of these facts make it difficult for the authorities to cope with infectious diseases.

In addition to more modern methods of disposing of sewage, there is evidently need of constant, intelligent supervision over these people on the part of conscientious experts. Why more of them do



Fig. 83. Creek into which the sewage of a large town enters.

not die of typhoid is a wonder. The same kindly Providence which keeps an intoxicated man from harm must be caring for them in their blind ignorance. We left the locality impressed with the existence of the following significant factors: Exposed foulness of all kinds, including pathological excreta, in close proximity to human food; an enormous number of flies congregating in towns

and settlements where an abundance of moisture and filth were found; absence of screens on windows and doors, and dense ignorance and indifference on the part of the miners. We could draw, from our visits, only one conclusion, that the typhoid fly was the agent for the spread of typhoid in that locality; as well as for the occurrence of a mild form of dysentery which appeared there in July and August. This dysentery appearing in mid-summer, at a time when the water supply was above suspicion, and differed from the water-caused dysentery (prevalent there in May, and directly traceable to the water supply), by being mild, causing but little pain and nausea, and but little or no fever. Patients lost but little time from work.

For the most part, health officials in the towns visited are doing all they can to better the conditions outlined above, and it must be borne in mind that the Iron Range is not the only locality where such conditions prevail. Outbreaks of this sort may and do occur wherever filthy conditions accompanied by ignorance and by house flies occur. We insert here a few illustrations emphasizing these conditions in the localities visited. It is encouraging, in this connection, to note the presence of splendid schools on the Iron Range, of night schools well patronized, and of a class of men who believe in the education and betterment of the conditions of the foreign population, for business reasons, even if not influenced by altruistic motives.

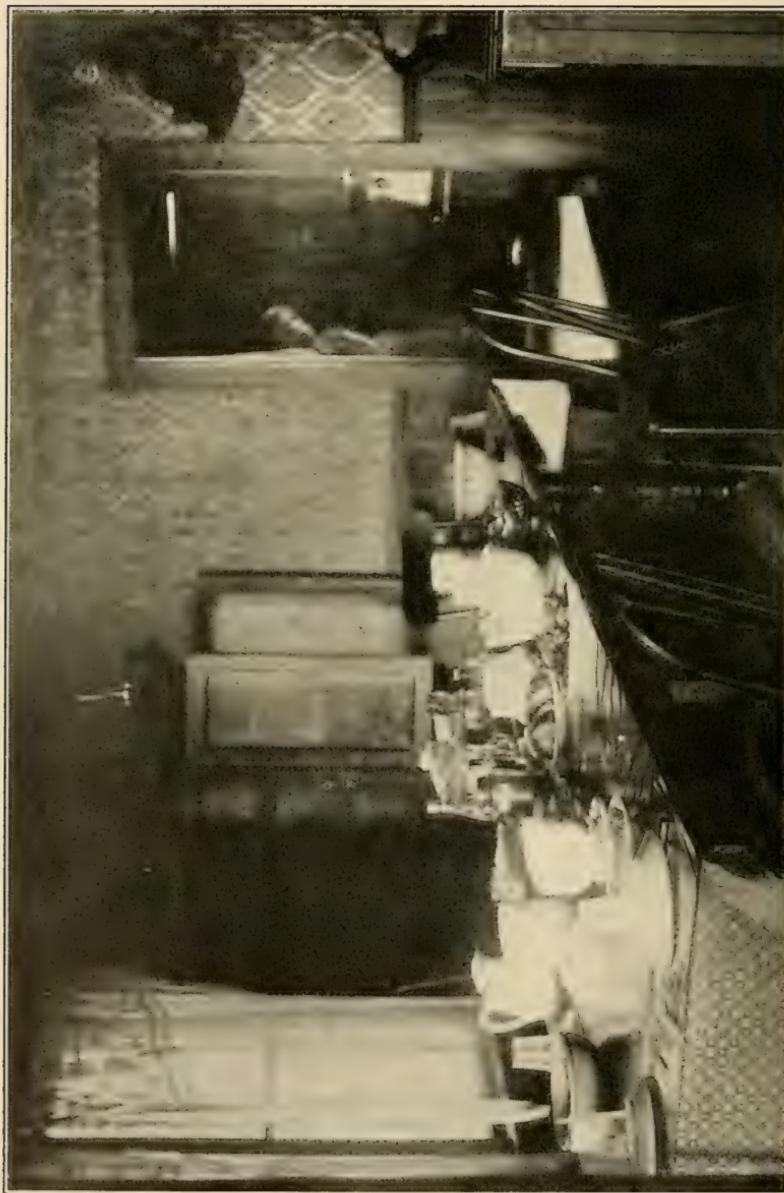


Fig. 84. A small table in a miners' boarding house. Food is exposed on these tables at all times.

ORCHARD AND GARDEN SPRAYING.

Introduction.

The following article on "Orchard and Garden Spraying" is the result of the collaboration of A. G. Ruggles of the Division of Entomology, and E. C. Stakman of the Division of Plant Pathology. Its appearance at this date is timely, and there is much demand for the information contained therein.

By the up-to-date orchardist spraying is considered as essential as any of the other processes necessary to the production of good fruit. It is regarded in much the same light that insurance is to the householder. Without spraying one runs the risk of considerable loss. To spray intelligently one should know just what he is spraying for, and it is nearly always essential that he should know at least the main features of the life history of the pest sprayed against, be it insect or disease. In the following pages we have endeavored to give brief life histories, and thus show the reason for spraying with such and such a compound in each case. Very often we can advantageously use a fungicide at the same time we use an insecticide. It is advisable to do this wherever possible. In fact, when spraying against a known insect, it is always good policy to combine even if not absolutely sure of the disease to be sprayed against. Sometimes, as with the lime-sulphur washes, a spray is both an insecticide and a fungicide. Arsenate of lead has a small fungicidal value, and when added to the lime-sulphur wash this fungicidal value is increased.

A few precautions are perhaps necessary, viz.:

1. Never spray when the trees are in bloom. A day's delay at this time will not materially affect the result of the spray. Bees and many other insects are very numerous at this time, fertilizing the flowers. A spraying compound thrown on them will lessen the amount of fruit set and destroy the honey bees.

2. Sprays recommended for the dormant season should never be tried when the trees are in leaf.

Before taking up the insecticides and fungicides in detail a general idea of the use of these killing-compounds may be desirable.

The "cide" of these words means "kill." An insecticide is something that will kill an insect; a fungicide is something that will kill a fungous disease. Different kinds of compounds are used for the different kinds of insects and diseases. There is no one spray that is the "cure-all" for everything. For instance, insects that bite, like caterpillars and beetles, take one kind of insecticide; insects that suck, like plant lice and scales, require another kind of insecticide. One fungicide is good for one disease, but it may be worthless against another disease. The insecticides are usually separated into three groups:

1. Gaseous insecticides. These are used in an enclosed space against either biting or sucking insects. Hydrocyanic acid-gas, carbon-bisulphid, and tobacco smoke come in this group.

2. Contact insecticides. These are used against insects that suck their nourishment from plants through a proboscis-like beak, or against biting insects that cannot be induced to eat the parts of the plant covered with an internal insecticide. In this group are found the lime-sulphur washes, crude petroleum, kerosene, soaps, miscible oils, etc.

3. Stomach or internal insecticides. These are used against insects that eat the foliage. The most important of these, like arsenate of lead, Paris green and arsenite of lime, contain arsenic in some form, and are called arsenical insecticides. The killing ingredient in these insecticides is not soluble in water, but is in the small particles of matter that remain in suspension in the liquid.

The fungous diseases of plants are caused by minute parasitic plants known as fungi. Fungi, having no green coloring matter (chlorophyll), are reduced to the necessity of getting their food from other plants or animals, or from the dead remains of plants or animals. These fungi are composed of a great many threads, which gain entrance to the tissues of the host plant, and absorb their nourishment from it. Minute reproductive bodies, known as spores, are produced. One fungus may produce more than one kind of spore; during the growing season it may produce one kind, which is especially well fitted to reproduce the plant very rapidly, while later in the season it may form another kind of spore which will live during the winter and germinate the next spring.

The cold-resisting spores may live during the winter in the soil, on the seed, on leaves, rotted fruit, or in rubbish. Further, the threads of the fungus may themselves live during the winter; they

may persist in the seeds, on mummied fruit, or, in the case of shrubs and trees, in the twigs. Each fungus has its own life story: it gets into the habit of going through its life cycle in a definite and fairly constant way. It may require, during the course of its complete development, two different kinds of plants. For instance, the rust of Wealthy apples is caused by a fungus which lives in red cedars in the winter and on apple trees in the summer. It is necessary, then, in order to effectually prevent fungous diseases, to know the life habits of the fungi causing them.

Preventive and curative measures are various. Spraying is resorted to when it is possible, by covering plant parts with some mixture either to kill superficial fungi like powdery mildews, or to prevent the spores from germinating properly and thus infecting the plant. If the fungus gets inside the twigs or branches, pruning must be resorted to, while if it lives on decayed or dried fruit, leaves or rubbish, these should be removed and burned. Seed disinfection is necessary in case the seeds are affected; such treatment is of value in preventing diseases like potato scab. Then, too, if the spores of the fungus persist in the soil, retaining their vitality for considerable periods, it is necessary to rotate crops or sterilize the soil. Again, it may be necessary, when a fungus requires two different plants for its complete development, to remove the so-called alternate host. Such a necessity often arises in dealing with apple rust; the removal of red cedars from the vicinity of the apple orchard prevents the rust from living through the winter. Some fungi gain entrance to their hosts mainly through wounds; obviously, in such cases, great care should be exercised in avoiding injuries, and in disinfecting and covering all wounds. Some varieties of fruit are more resistant to a certain disease than others: these should, naturally, be selected. Weather and soil conditions often affect to a remarkable degree the prevalence and severity of a disease; it is not always possible to control these factors, but some precautions can always be taken both in the greenhouse and in the field: the proper kind of soil can usually be selected, good ventilation can be provided for, and excessive shade can be avoided.

Fungicides may be applied in different ways: they are usually used as steeps or sprays, sometimes as washes. The subject of sprays is still somewhat problematic. Bordeaux has been regarded as a "cure-all," but, under certain circumstances, it is objectionable. It stains the plant parts with which it comes in contact, so is unfitted for use on ornamental plants or ripening fruit. Further, the

copper salts which are formed have an injurious effect on certain plants, among them the plum. In such cases, it is necessary to employ some other fungicide, or, at any rate, to use very weak bordeaux. Nevertheless, bordeaux, although being replaced to a certain extent by some newer fungicides—notably the self-boiled, lime-sulphur mixture, is probably better, for general purposes, than any other. The proper strength of bordeaux is still somewhat uncertain; in fact it varies with conditions. The 5-5-50 formula has been regarded as standard, but excellent results have been obtained with weaker solutions, so it is probable that, for general work, a 4-4-50 mixture will be sufficiently strong.

The following are the fungicides in common use as sprays: bordeaux mixture, lime-sulphur wash, self-boiled lime sulphur, ammoniacal copper-carbonate, potassium sulphide. In addition to these, flowers of sulphur is often used, especially against powdery mildews, while corrosive sublimate and formalin are used in seed treatment.

The amount of spray to apply will vary with the size of the tree. A tree having a spread of twenty-five feet in full leaf will require at least four gallons. The person just learning to spray ordinarily does not put on a sufficient amount, but stops before even half of the required amount has been given. This is one of the main reasons why spraying is not as successful as it should be in the hands of the beginning orchardist. A man must also learn to apply the spray evenly and thoroughly, and, with possibly one exception, not in the form of drops, but in a very fine mist.

In our discussion of the plant pests, there are perhaps many forms that we have not mentioned. It may be that they have never been reported to us as being found in this state, or perhaps are only of local importance. The Divisions of Entomology and Plant Pathology of the Experiment Station are always willing and anxious to find out the various pests present in the state, and will welcome correspondence and specimens of diseased plants, or, in the case of insects, the enemies themselves.

INSECTICIDES AND FUNGICIDES.

Alphabetically Arranged.

AMMONIACAL COPPER CARBONATE. This is not as good for general purposes as bordeaux mixture. It is used instead of bordeaux when it is desirable to avoid the spotting of leaves or ripening fruit. It is prepared as follows: Weigh out the proper

amount (5 oz.) of copper carbonate and use just enough ammonia to dissolve it. If the ammonia is strong it should first be diluted with water. Then add the proper amount of water (50 gallons).

ARSENATE OF LEAD. Arsenate of lead is one of the most valued of the arsenical insecticides. It has in many cases entirely displaced Paris green with orchardists, and there are at least two good reasons for it.

First. The arsenate of lead has great adhesive qualities. It will not wash off even in quite heavy showers of rain. Some of our experiments here at the Station showed the presence of this arsenical on the leaf in sufficient quantity to kill insects ten weeks after spraying.

Second. It can be used in any strength without burning the foliage of the plant sprayed.

Third. It has some fungicidal properties that are increased when added to *Lime Sulphur*.

Arsenate of lead can be made at home or bought in paste form on the market. Ordinarily it will be easier to buy the prepared material.

The formula of the home-made is as follows:

Twenty-two ounces acetate of lead (sugar of lead) dissolved in 2 gallons of warm water in wooden pail.

Eight ounces arsenate of soda dissolved in one gallon warm water in another wooden pail.

These two solutions poured together make a sufficient quantity of poison for 50 gallons of spray.

Three pounds of the commercial paste are recommended for 50 gallons of spray.

ARSENITE OF LIME. This is essentially a home-made preparation. If made properly it is just as good as Paris green and is much cheaper. The best method of preparation is as follows:

White arsenic, one pound.

Crystal sal soda, four pounds.

Water, one gallon.

Boil these in an iron kettle for twenty minutes or until thoroughly dissolved. *The kettle must be kept exclusively for this purpose.* The soluble material obtained is arsenate of soda, and can be stored away in jugs or bottles, labeled "poison," for future use.

For 40 or 50 gallons of spray take $1\frac{1}{2}$ to 2 pints of this solution, and 4 pounds of freshly slaked lime. Dilute the lime and strain, then add the quart of the stock solution. Pour into the spray barrel and it is ready for use.

BORDEAUX MIXTURE. This is made of copper sulfate (blue stone), quick-lime and water. It is used in various strengths, the 5-5-50 being probably that in most common use, although the 4-4-50 will probably give equally good results. 5-5-50 simply means that 5 pounds of copper sulfate, 5 pounds of lime and 50 gallons of water have been used in the preparation of the spray. In the same way 2-2-50 would mean that 2 pounds of copper sulfate, 2 pounds of lime and 50 gallons of water have been used. The number of pounds of copper sulfate is indicated by the first figure, the number of pounds of lime by the second, and the number of gallons of water by the third.

One of two methods may be used in making bordeaux. Either it may be made directly or stock solutions may be made and these stock solutions used whenever the fungicide is needed. In making the spray directly, take 5 pounds of copper sulfate, put it into a coarse gunny sack and hang it in a barrel containing 25 gallons of water. Being suspended, the copper sulfate will dissolve much more readily than if put into the bottom of the barrel. Now slake carefully 5 pounds of good, quick lime, using just enough water to slake it slowly. Be sure that the lime is not all air-slaked. When the lime is slaked, add enough water to make 25 gallons. Now stir it carefully and then pour together the copper sulfate solution and the milk of lime. It is desirable to have a slight excess of lime, since it prevents any injurious action of the copper salts. If there is an excess of copper, foliage injury is liable to result. Therefore two simple tests should be made to determine whether or not the mixture is safe to use. Take a piece of newly-filed iron or steel and put it into the mixture for about a minute. If it has a copper coating when it is taken out, there is an excess of copper, and more lime should be added. To determine whether or not there is a sufficient amount of lime in the mixture, pour some of it into a flat dish and blow on it for a few moments. If a film forms on the surface, enough lime is present; if not, more should be added. In making stock solutions, dissolve copper sulfate in water at the rate of 1 pound to 1 gallon of water. Slake the lime slowly in another receptacle and, when slaked, add water until a thick, lime-milk, 1 pound to 1 gallon of water, is formed. When using the

stock solution in making up the spray mixture, 1 gallon of copper sulfate solution represents 1 pound of copper sulfate and 1 gallon of lime-water represents a like amount,—more or less, depending on the amount of water used in making the stock solution. The proper amount of stock solutions should be diluted separately before they are poured together. The stock solution of lime should be first run through a fine mesh sieve to remove all lumps which might clog the nozzle of the sprayer.

CARBON BISULFIDE: This is a very inflammable liquid that volatilizes readily when exposed to the air. It is one of the gaseous insecticides used against weevils, etc.

COPPER SULFATE WASH:

Copper sulfate, 3 pounds.

Water, 50 gallons.

This is used as a wash on dormant trees for prevention of such diseases as apple scab. It must never be used on trees after the buds have burst.

CORROSIVE SUBLIMATE:

Mercury bichloride (corrosive sublimate), 2 ounces.

Water, 15 gallons.

This is an extremely poisonous mixture and should be handled with great care. It is very effective against potato scab. It should not be made in tin vessels as it corrodes them.

CRUDE PETROLEUM: This is an oily, inflammable liquid that when refined yields such products as paraffin, lubricating oil, kerosene, etc. A petroleum having a specific gravity of 43 degrees (Baume scale), is an excellent insecticide for scale insects. In fact it was used very successfully against the San Jose Scale until the lime-sulfur wash was found to be better.

FORMALIN:

Formalin (40% formaldehyde), one-half pound.

Water, 15 gallons.

This is used in treating seed for prevention of such diseases as potato scab.

HELLEBORE: This is a stomach or internal insecticide. It is not poisonous to man as are the arsenical insecticides, and therefore is used where there is danger of poison remaining on parts to be eaten. It is often used on currants and gooseberry bushes when the berries are beginning to ripen. This material can be used in the dry form, or as a spray at the rate of 2 or 3 ounces to a gallon.

HYDROCYANIC ACID GAS: This gas is made by dropping potassium cyanide into sulfuric acid and water. The fumes are deadly to all kinds of animal life, and the gas is used only in special cases. As this gas is fatal to human life as well as to insect life, it should be used only by an expert.

IRON SULFIDE MIXTURE: This is a comparatively new, but, according to Circular No. 58 of the Bureau of Plant Industry, U. S. Department of Agriculture, very promising fungicide. It was tried in particular on apples, and gave splendid results, both in preventing fungous diseases and in non-injurious effects on the fruit. In preparing this fungicide, it is recommended that a self-boiled, lime-sulfur mixture be prepared as previously described except that 10 pounds of lime and 10 pounds of sulfur are used. The mixture is diluted to 40 gallons and then 3 pounds of iron sulfate, (copperas) dissolved in about 8 gallons of water, is added.

KEROSENE: This is an excellent contact insecticide, the merest particle of it coming in contact with any part of the anatomy of an insect is fatal. Pure kerosene, however, will burn the leaves of plants, consequently it is only recommended to be used in the pure form when trees are dormant, or against insects off of plants, for instance, the killing of grasshoppers by hopperdozers, or household insects, etc.

KEROSENE EMULSION: This is probably the best form into which kerosene can be put for spraying growing plants. A stock emulsion is made as follows:

Hard laundry soap, shaved fine, $\frac{1}{2}$ pound.

Water, 1 gallon.

Kerosene, 2 gallons.

Dissolve the soap in boiling water, remove from the stove and immediately add the kerosene; churn with a bucket pump until a soft, butter-like, clabbered mass is obtained. One part of this stock solution is added to ten or twelve of water for spraying. If the stock solution is properly made this can be used on tender foliage of plants for such insects as plant lice, etc.

LIME SULFUR: Within the last few years this wash has become very prominent. It is one of the best scale insecticides yet discovered, and will kill the eggs of plant lice. As an insecticide it has an accumulative action, being more active a few weeks after spraying than at the start. Since coming into prominence as a

scale insecticide it has been found, quite recently, that in its several forms it is an excellent fungicide, and will, in many cases, replace Bordeaux mixture. There are several formulae for making this wash, three of which are appended.

The Boiled Mixture :

Best stone lime, 15 pounds (not over 5 % impurities).

Flowers of sulfur, 15 pounds.

Water, 50 gallons.

Slake the lime in a small quantity of hot water, add the sulfur gradually and stir thoroughly. Dilute the mixture to 15 gallons with water, and boil in an iron kettle, or cook by steam in a barrel for forty-five minutes. Fill the vessel with water to the required 50 gallons; strain the wash through a fine mesh strainer, and apply hot.

This wash should be applied in the fall after the leaves have dropped, or in the spring before the buds open. Spray thoroughly, covering all parts of the tree.

CENTRATED LIME SULFUR: When stored away it is best to cover the solution with a layer of oil about an eighth of an inch thick. This will prevent evaporation, and the forming of a crust on the material. The material should not be stored where the temperature would go very low.

In spraying with this mixture definite dilution must be made, and to do this a Baume scale is required. The amount of dilution will vary from one part of this concentrate in nine or ten parts of water to one part concentrate in thirty or more parts of water. This concentrated material is now on the market in a commercial form, and is generally very reliable.

Formula :

80 Pounds sulfur.

40 Pounds best stone lime (95% calcium oxide).

50 Gallons of water.

The cost of making this material will depend on the amount that can be made at one time, and the cost of material and labor. The average cost is about \$2 per barrel of 50 gallons. Usually it is not practicable to make as much as 50 gallons at one time, consequently the following directions are for making only 25 gallons. Live steam run in a barrel, or fire under an iron kettle may be used in boiling.

Place five gallons of water and forty pounds of the sulfur in the vessel and apply heat until the sulfur becomes a smooth paste.

stirring constantly. Now add ten gallons of water and the twenty pounds of lime and boil for forty-five minutes. Add water to make the twenty-five gallons. When cooled to 65 degrees F. test with the Baume scale, the reading should be about 33 degrees.

As a scalecide to use in the dormant season this should be diluted 1-10 (i. e.) one part of the above formula diluted with nine parts of water, and 6-10 pounds of stone lime added to every fifty gallons of the spray.

As a fungicide for summer use dilute 1-30. (One part of stock formula diluted with twenty-nine parts of water.)

SELF BOILED LIME SULFUR:

Lime, 8 pounds.
Sulfur, 8 pounds.
Water, 50 gallons.

This spray is especially valuable in cases where bordeaux is injurious to foliage or fruit. The stone fruits, such as plums, are particularly susceptible to bordeaux injury, while some varieties of apples are badly russeted by it. There is slight danger of injury by the self boiled lime sulfur preparation and it is an efficient fungicide when properly made. It stains the fruit as does bordeaux. In making it, eight pounds of lime of good quality should be placed in a barrel, and enough water to nearly cover it should be added. While the lime is slaking, add sulfur which has been run through a sieve to break up the lumps. The sulfur should be thoroughly stirred into the slaking lime, enough water being added to make a pasty mass. The barrel should not be covered, in order to retain the heat, and the contents should be occasionally stirred. The time required varies with the quality of the lime; if the lime acts quickly, five to ten minutes will be sufficient, while if it acts slowly, fifteen minutes may be necessary. It should not be allowed to stand too long, because it may, in that case, be injurious to foliage. Now add a little water, stirring the mixture while it is being poured in. Then add enough water to bring the total up to 50 gallons. In applying the spray it is necessary to have a good agitator in the sprayer.

MISCIBLE OILS (Oils that will mix with water):

There are several oils on the market that are miscible with water. These make a good winter spray for scales, and are also excellent summer sprays against the same insects. Great care, how-

ever, must be taken to obtain the right dilution as per directions given on container, or burning of the leaves will result.

PARIS GREEN: This is the old stand-by, and is still used by many where an arsenical insecticide is necessary. Our experiments on orchard trees and other reports indicate that arsenate of lead is better in every respect, although our potato expert at the Experiment Station, Mr. Kohler, who has experimented with many of the stomach insecticides for potato beetles, finds Paris green the most satisfactory for these pests. It is generally used at the rate of 1 pound to 50 gallons of spray. In using always first make a paste of the Paris green and water, and then add to the spray material. If water alone is used, 2 to 3 pounds of stone-lime should be added. If Bordeaux mixture is used the addition of lime is not necessary.

POTASSIUM SULFIDE (Liver of Sulfur):

3-5 Ounces of potassium sulfide.

10 Gallons of water.

This is used in place of bordeaux to avoid spotting of foliage and fruit. It is considered to be especially effective against powdery mildews, such as the gooseberry mildew. It is also quite extensively used in greenhouses and on shrubbery.

PYRETHRUM OR INSECT POWDER: This is a powder from the ground up flowers of the pyrethrum plant. It is a contact insecticide and is used against fleas, cockroaches, etc. If the powder is burned in a room the fumes will destroy mosquitoes and flies.

THE RESIN-LIME MIXTURE: This is a mixture often used in combination with a fungicide or an insecticide to insure the sticking of the necessary poisonous material to smooth, glossy leaves.

Formula :

Pulverized resin, 5 pounds.

Concentrated lye, 1 pound.

Fish or other animal oil, 1 pint.

Water, 5 gallons.

Place the oil, the resin and one gallon of the water in an iron kettle, and heat until the resin softens, then add the lye and stir thoroughly. Add to this four gallons of hot water, and boil until a little mixed with cold water gives a clear, amber colored liquid. Add water to make up to the five gallons.

This is our stock solution. In spraying with Paris green or Bordeaux mixture take two gallons of this mixture, dilute it to 10 gallons and add to 50 gallons of spray.

SOAP: Ordinary soap is a valuable contact insecticide.

Formula:

1 Pound Ivory soap or other soap of known quality.

14 Gallons of water.

Boil the soap in five or six gallons of water until dissolved; dilute with water to 14 gallons and spray while still warm. It is recommended for plant lice, red spider, etc.

SULFUR:

Flowers of sulfur is often dusted on plants to prevent such diseases as the powdery mildews.

TANGLEFOOT: Is a sticky material often used on trunks of trees, etc., to prevent caterpillars from crawling up to the leaves, or to prevent wingless females of some insects crawling up the trunk to lay their eggs.

TOBACCO: Tobacco is a very important contact insecticide. As a powder it is one of the best remedies for root-lice on trees. It may also be used in the form of dry stems applied in the same way as the dust. As a decoction of the stems, it may be used as a spray against plant lice. This decoction is also good for lice on cattle. Tobacco smoke, when generated in an enclosed space, kills numerous soft-bodied insects. There are several commercial forms of tobacco decoctions on the market, namely Nicotine and Nicofume, the latter very highly recommended by green house men for the green fly on lettuce. We have found it excellent for all kinds of plant lice.

WHALE OIL SOAP: This is a commercial product, and is a good contact insecticide, particularly for soft-bodied insects like plant lice and slugs.

Insects and Diseases.

Apple.

CODLING MOTH: The larvae of this moth are the ones that make the most of our wormy apples. The larvae leave the apples in the fall and hibernate in cocoons, usually under loose bark of the trees. The adult lays eggs on the leaves or young fruit soon after the blossoms fall. Over ninety per cent. of the larvae find their way into the calyx end of the fruit. Here they eat their first big meal. Consequently if one can fill this calyx cup with a poison, practically all of the first generation of larvae will be killed, and the

small number remaining will not seriously injure the fruit later. Any of the arsenical insecticides can be used.

CURCULIO: In this state the curculio that works on the apple is the plum curculio. The adult curculio hibernates, and on the approach of warm weather in the spring is ready to take its first meal. At this time they will attack the swelling buds, consequently if the buds are covered with an arsenical insecticide many curculos will be killed. Later the female curculio lays the egg in the fruit, and then makes the familiar crescent-shaped mark. The egg hatches into a grub, making the fruit eventually drop. If the young fruit can be kept covered with an arsenical spray many less eggs will be laid, and many adult female curculos killed at this time.

SCALE INSECTS: The principle scale insects found in this state are the oyster-shell scale and the scurfy bark louse. The San Jose scale is probably present, as it has been found in the states surrounding Minnesota. These are sucking insects, consequently a contact or gaseous insecticide must be employed against them. The insects are covered with a scaly armor that ordinary insecticides will not penetrate. Fortunately the discovery of the lime-sulfur wash has very nearly solved the difficulty with these pests. The lime-sulfur attacks the scaly armor and kills the insect or the eggs beneath. The diluted lime-sulfur wash or the self-boiled is excellent to keep these insects in check during the growing season.

SCAB: This fungus attacks fruit, leaves and young twigs. On the fruit small, olive brown patches are first formed. These later rupture the skin of the apple and large scabby spots or cracks are formed. These permit the entrance of rots later. On the leaves and twigs dark patches of velvety texture are formed, sometimes with an olivaceous tinge. The disease probably lives over on the fallen leaves and, possibly to a certain extent, on twigs and fallen fruit. It is liable to be especially prevalent when the weather has been damp and cool.

If the disease has been very bad the previous year, a thorough spraying with copper sulfate before the buds swell may be advisable. Under ordinary circumstances a spraying with 4-4-50 bordeaux

before the flowers blossom, another after the petals have fallen, and a third about ten days or two weeks later, followed by a fourth will probably be sufficient. Self boiled lime sulfur and iron sulfide mixtures have also been used with considerable success.

RUST: This is usually formed on the leaves, producing orange colored spots; it may also be found on the fruit, and, less frequently, on the twigs. If examined closely, the orange spots are seen to consist of many cup-shaped bodies with fringed edges. It is especially bad on wealthy apples when it attacks the blossom end of the fruit. The rust lives over the winter on the red cedar, which it produces the so-called cedar apples from which infection of the apple again takes place in the spring, especially following moist weather.

Spraying for scab will keep this in check to a certain extent, but not completely. Obviously, however, red cedars, whenever possible, should be removed from the vicinity of the orchard, or at least the cedar apples should be cut away early in the spring or late in the fall. If the latter is not effective, the cedar trees must be removed. Neighbors should co-operate.

BITTER ROT—RIPE ROT: This rot is found on fruit and branches. On the fruit it appears first as small, brownish patches beneath the skin. These patches rapidly enlarge until they are of considerable size; they then form sunken, often wrinkled areas, which are often corky, and very bitter around the edges. The fruit is especially liable to attack while it is ripening, but may become infected earlier. Hot, damp weather is very favorable to the spread of the disease which may cause great loss within a week or ten days from the time it first appears.

On the branches it forms cankers which are usually round or somewhat elongated spots, sometimes several inches long. The bark becomes very dry, cracks, and causes a characteristic sunken, wrinkled appearance. The disease probably persists largely in these cankers, but also on the "mummied" fruit.

All rotted apples should be destroyed and the cankered twigs pruned out. If spraying to prevent this disease alone, it would probably be early enough to make the first application of bordeaux or self boiled lime sulfur about a month after the petals have fallen, and to continue at intervals of about two weeks until the fruit is

nearly ripe. Pruning and destroying the diseased apples, together with the sprays used for scab, will keep the disease in check.

BLACK ROT: This quite closely resembles the bitter rot. It forms brown, sunken areas on the fruit; these are often darker in color than those formed by bitter rot. The brown color changes to a darker color until finally the apple dries out, leaving only a blackish, much shrunken remnant. Beneath the skin, numerous small black dots may be seen. The fungus gains entrance to trunks also, usually through wounds or sunscald cracks in the spring, inflicting such damage that large limbs may be killed. A number of so-called leaf spots are also probably due to this fungus.

The treatment is the same as that for the bitter rot.

FIRE BLIGHT: This is a bacterial disease which is no doubt spread very largely through the agency of insects. When they visit the flower, they may have some of the bacteria adhering to their mouth parts, thus permitting the organisms to get into the nectar, where they multiply with amazing rapidity, finally getting into the twig. Boring or biting insects may also cause the infection of older branches. Affected twigs first present a water-soaked appearance, but later the bark is ruptured and gummy exudations appear. The fruit may also be attacked. The leaves of affected branches yellow and dry, but remain on the twigs; usually they do not fall in the winter.

Pruning in the fall or winter should be resorted to if the disease is prevalent. Precautions must be taken to disinfect pruning knives used, or the disease may be spread by means of them. The wounds should also be properly cared for. For disinfecting use the corrosive sublimate preparation. Prune back six inches or more below the infection. Prune out all infected twigs. Neighbors must co-operate.

LEAF SPOTS: There are various spots which are caused by different fungi. Almost all, if not all, can be controlled by the sprays which are applied to prevent the other diseases mentioned.

POWDERY MILDEW: This mildew has the characteristics of powdery mildews in general. It is usually most prevalent on nursery stock where it may cause considerable damage. As the leaves begin to unfold, an application of ammoniacal copper carbonate should be made. This should be continued at two week intervals.

A COMBINATION TREATMENT FOR INSECTS AND FUNGOUS

PESTS: In dormant season spray with lime sulfur wash. As the buds are breaking spray with arsenate of lead and lime-sulfur (self-boiled), or with arsenate of lead and Bordeaux mixture. Repeat just after blossoms fall. Repeat in two weeks. Repeat at intervals of two or three weeks until the fruit begins to ripen and substitute ammoniacal copper carbonate for the Bordeaux mixture.

Asparagus.

RUST: The most conspicuous stages of the rust appears as brown eruptions, followed later in the season by black, or brownish black patches of winter spores.

It has been observed that the disease is most prevalent on dry soils, so a good rich soil very carefully cultivated and kept fairly moist renders it less destructive. It is also favored by heavy dews, and moist conditions, so there should be good aeration. In the fall all diseased stalks should be collected and burned. Spraying has been partially successful. Resin bordeaux should be applied at intervals of about ten days beginning when the shoots are small. However, while shoots are small and rapidly growing, it may be necessary to spray more frequently.

Bean.

BEAN AND PEA WEEVIL: The beetles usually appear on the vines when the plants are in blossom, the eggs being deposited on the surface of the young pod. The hatched larvae bore into the pod and enter the young seed, where it grows to maturity. In this state the pea weevil probably remains within the seed until planted the next spring. It does not breed in dry peas. The bean weevil, however, will breed in dry beans. For the pea weevil the best remedy is to hold the seed over a year before planting, keeping in a tight receptacle. Fumigating the infested seeds with carbon bisulfide is good. Heat also (130 to 140 degrees F.) will kill the insects in stored material.

ANTHRACNOSE: This produces the familiar reddish brown or darker colored sunken spots on pods, stems and leaves. The disease gets into the seed and is carried over the winter in this way. No seed treatment has been developed, so it is absolutely essential to get seed from healthy pods if the disease is to be avoided. It spreads only when the plants are wet, so no cultivation should be done when there is moisture on the vines. Spraying is of very doubtful value; the essential thing is to get seed from healthy pods.

All plant remains and rubbish should be destroyed in the fall. There is some question as to varietal resistance; wax varieties are said by some to be least resistant while the limas are more resistant.

DOWNTY MILDEW: The fungus attacks mostly the pods, but may also be found on the leaves and, in some cases, on the stems. It produces white patches which may become so numerous as to cause the pods to die. In some cases, when the disease is especially severe, it also gets into the seeds. It is pretty well establishd that insects aid very greatly in its spread.

Clean seed should be selected, all old vines should be destroyed in the fall and, if the disease has been particularly bad, a rotation of crops may be necessary. Careful spraying with bordeaux has been found to effectually prevent the occurrence of the disease.

BRIGHT: All above ground parts may be affected by the disease. It is most noticeable on the leaves and pods, producing on the leaves large, irregular brownish patches which later become dry and brittle. On the pods watery brown spots with no very definite boundaries are produced.

The disease is of bacterial origin. The first infection is generally supposed to come from the seed in which the bacteria have lived over, and is then quite largely spread by insects. Seed should be selected from fields in which there was no infection, all affected parts should be burned, and a crop rotation should be practiced.

RUST: Small pustules, about one-sixteenth of an inch in diameter, are formed usually on the lower surface of the leaf. Just opposite these pustules, on the upper surface, pale yellowish spots appear. Later these pustules break open, liberating a mass of dull reddish brown spores. The disease has not been reported as being very troublesome. Burning of dead parts in the fall and clean culture methods should help keep it in check.

POWDERY MILDEW: Grayish patches, appearing as though dusted with a grayish powder, appear. Usually the disease is not very destructive. It can be controlled by means of dusting with sulfur or spraying with potassium sulfide.

Beet.

The principal insects of the beet are the leaf-eating forms, which can be controlled with any of the arsenical insecticides.

LEAF SPOT: Brown spots, with a purplish tinge around the edge and with a grayish center, appear. They may become dry and

fall out, leaving many holes in the leaves. This occurs also on sugar beets.

Spraying with 5-5-50 bordeaux, first when the plants are six weeks old and then at ten-day intervals, gave a large increase in yield over unsprayed plots in the east.

SCAB: See Potato Scab.

Cabbage and Cauliflower.

The principal enemy is the so-called cabbage worm, the larvae of the common white cabbage butterfly. The ordinary arsenical insecticides readily keep these in check.

BLACK ROT: This is caused by bacteria. The first symptoms of the disease appear as a yellowing of the edges of the leaves. Later the leaf veins become black, and the outer leaves may fall off, in bad cases leaving the stem with only a few leaves near the top. Moist conditions are especially favorable to the spread of the disease, since the bacteria enter through the water pores at the edge of the leaf. All heads which show signs of infection should be rejected, since a soft rot which may spread to the other heads is likely to ensue. Such heads should not be fed to stock, the manure of which is to be used on land used for raising cabbage. Clean cultivation and rotation should be practiced, since the disease may live over in the soil. It may also be carried over in the seed, so only clean seed should be made. As an extra precaution, seed should be soaked 15 or 20 minutes in formalin, 1 pound to 30 gallons. The same disease occurs also on many other plants of the mustard family, both wild and cultivated, such as shepherd's purse, common wild mustard, kohl rabi, brussels sprouts, kale, rape, turnips, etc. This should be taken into account in attempting to control the pest.

CLUB ROOT: Club root is caused by a slime mold, an animal fungus. It causes, on plants of the mustard family, large swellings or galls on the roots which later decay. The above ground parts are affected by the general decrease in vigor so that, in many cases, they fail to head.

All refuse and diseased parts should be destroyed, and care should be taken not to use manure which may have come in contact with diseased parts. Since the soil, when once infected, may remain so for several years, a rotation should be practiced. An application of air-slaked stone lime, at the rate of about 75 to 80 bushels

per acre, has proven very beneficial. It should be applied a few weeks before planting and should be very thoroughly worked into the soil.

DOWNY MILDEW: The downy mildew occurs usually in the seed bed—seldom in the field. It produces grayish white patches on the under surfaces of the leaves. Opposite the spots, on the upper surface of the leaves, there are yellowish, somewhat shrunken spots. Spraying with bordeaux will control the disease.

Celery.

LEAF SPOT—EARLY BLIGHT: Yellowish, angular spots, with somewhat raised borders, appear on both sides of first the outer and then the inner leaves. As the disease progresses, the centers of the spots become grayish in color; the leaves wilt and dry. Muggy weather is favorable to the spread of the disease.

In order to control it, spraying should be begun early—in the seed bed—and continued at intervals of ten days or two weeks. Either 5-5-50 bordeaux or ammoniacal copper carbonate may be used.

LATE BLIGHT: Leaf spots, similar in the early stages to those of the early blight, appear on the leaves. Later numerous small, black dots appear on the affected portions. The leaves may rot away entirely, either in the field or in storage. The trouble in storage is greatly increased if the celery is kept in moist, poorly ventilated places.

Control measures may be taken as indicated under early blight. It is especially important to begin spraying as soon as the plants come up. If the plants are at all affected, the leaves should be dipped in ammoniacal copper carbonate before being stored.

Cucumber.

CUCUMBER BEETLE: In the adult condition these striped beetles eat the leaves and so can easily be combated with the arsenical insecticides. In the larval form they sometimes do great injury to the roots of cucumbers. We have had good success against this form by using tobacco dust on the exposed roots of the plants.

DOWNY MILDEW: The downy mildew produces yellowish spots, irregular in outline, first upon the older and then upon the younger leaves. In warm weather the spots may spread rapidly, eventually covering the entire leaf, which then dries and may fall.

Flowers are produced, but few fruits are matured, and those which come to maturity are usually small and misshapen.

Spraying to control the pest should begin as soon as the vines begin to run, and should be continued every ten days or two weeks. 4-4-50 bordeaux may be used, although it is often recommended that the first spraying be made with 3-6-50 and the subsequent ones with a 4-4-50 mixture.

POWDERY MILDEW: This produces the powdery patches characteristic of powdery mildews. Usually it is not very destructive and will yield to the treatment applied to control downy mildew.

SCLEROTINIOSE OR SCLEROTIUM DISEASE: In the greenhouse this disease may do considerable damage, although out of doors it occurs but rarely. The stems become soft and yellowish, finally drying up. A white, fuzzy mass may also appear. Slender black storage organs may appear. Affected vines should always be removed before these storage organs appear and the place from which they were removed should be very thoroughly sprayed with bordeaux or some other fungicide.

WILT: This disease is of bacterial origin. It has not been found on cucumbers in Minnesota, but was found on squash in 1910, so a description will be given, since it is probably present. It causes the vines to droop and, finally to die. It is spread mainly by biting insects, and, possibly to some extent, lives over in the soil. Spraying to prevent other fungous diseases and insects will aid in preventing the spread of the wilt. Rotation of crops may also prove beneficial. Destruction of diseased vines is, of course, necessary.

TUBERCULAR OR WART DISEASE: The cucumbers are covered with knob-like protuberances which later may cause the entire fruit to become misshapen. Although considerable work has been done at this Station in attempting to control the trouble, no effective remedy has yet been found.

Currant.

The currant worm, the larva of a saw fly, is the worst insect pest of this shrub. As the insect eats the leaves, however, it is easily combated with a stomach insecticide.

CURRENT APHIS: This plant louse works on the under side of the leaves causing reddish, swollen discolorations. They are quite hard to combat, living as they do, entirely on the under side of the

leaves. A contact insecticide must be used, the spray being thrown against the lower surface of the leaves.

LEAF SPOT: There are at least two distinct fungi causing leaf spots on currant. The spots are usually circular in outline with a grayish brown center. The leaves may finally fall in serious cases, causing great damage.

To control the disease, spray with bordeaux as soon as the leaves unfold, and continue at intervals of ten days or two weeks until five applications have been made.

POWDERY MILDEW: The fungus produces grayish, cobwebby patches at first. These later become brown and felt like. Leaves, fruit and stem are attacked.

Potassium sulfide used at the rate of 1 ounce to 4 gallons of water is the most efficient spray. Spraying should be begun just as soon as the leaves begin to appear, and should be continued at ten day or two week intervals until at least five applications have been made. It may be necessary to add one or two more applications.

CANKER: The canker is produced as reddish eruptions on the stems; these eruptions may become dark later in the season. Twigs may be killed; in any case vigor is greatly reduced. Pruning may be necessary. However, since the disease enters largely through wounds, care in covering them or spraying with bordeaux, when such wounds occur, will be beneficial.

RUST: Usually the rust is not very injurious. No extensive experiments in controlling the pest have been made, so that only the destruction of affected parts can be recommended.

Ginseng.

BLIGHT: The leaves and stem are both attacked. Large, watery patches are produced on the leaves, and brown cankers are formed on the stem. The disease may spread rapidly and become very destructive. Infection in the spring seems to be caused by the spores which are on the ground. The plants are attacked as they come through the ground, the disease first appearing on the stems. In order to properly control the disease, it is necessary to spray the beds with copper sulfate, used at the rate of 1 pound to 10 gallons of water, before the plants come up. Then, as soon as they push above ground, they should be again sprayed. This should be done every other day until the plants are fairly well along. Resin bordeaux will adhere better than the ordinary mixture.

WILT: The leaves wilt, become yellowish and finally die. The stems become black and defoliated. Great damage may be done within a week. It is said that the disease will not appear unless the plants are weakened by the attacks of other fungi. Spraying for the blight should also keep this disease in check.

Gooseberry.

See Currant.

Grape.

LEAF HOPPERS: These are very active, insidious sucking insects, and consequently hard to combat. A contact insecticide, like kerosene emulsion or miscible oil will keep the insect in check.

BLACK ROT: The disease first appears on the leaves; it produces nearly round, tan colored or brown patches. Later it attacks the berries on which it appears first as small, brown or purple spots. These spots enlarge very rapidly until the entire fruit is covered. The skin does not usually rupture, but the berries shrink until they remain only as wrinkled, hard, dry mummies. Young shoots may also be attacked; in this case the spots are usually reddish and may cause a splitting of the shoot. The disease lives through the winter on affected parts; consequently all of these should be sprayed in the fall, and clean cultivation should be practiced. Just as the buds are beginning to swell in the spring, a very thorough spraying with bordeaux should be made. When the buds are unfolding, the second spraying should be given with 4-3-50 bordeaux, and this should be repeated at ten day or two week intervals. The number of sprayings necessary depends upon weather conditions; in warm, moist weather the disease is most destructive. If it is necessary to continue spraying until late in the season, ammoniacal copper carbonate should be substituted for bordeaux the last two times. This is done in order to avoid the spotting of the fruit.

DOWNTY MILDEW—GRAY ROT: The symptoms are those usually appearing as a result of downy mildew. A grayish, felty mass of fungus threads appears on leaves and berries. The berries eventually shrivel, but do not become hard and dry as in the black rot. If they are attacked after they are at least two-thirds grown, they become brown in color; for this reason the name brown rot is sometimes applied.

The control measures indicated under black rot will suffice. It is especially important that spraying be begun early in the season.

LEAF SPOT: In moist seasons irregular brown or black spots are produced on the leaves. They appear first on the under surface of the leaf. Use control measures indicated under black rot.

POWDERY MILDEW: The powdery mildew appears as circular, flour-dusted spots on all above ground parts of the plants. Under favorable weather conditions it may become serious, since the flowers may be attacked and then fail to set their fruit, while the berries themselves may be attacked and then cease growth, finally dropping from the vine. Lack of ventilation, excessive shade and damp situations are especially favorable for the spread of the disease.

Dusting with flowers of sulfur when the blossoms begin to open and repeated dustings as occasion may demand usually controls the pest effectively. The treatment under black rot is also effective.

ANTHRACNOSE—BIRD'S EYE: This appears on the canes as small, dark spots with sunken, ash colored centers; it weakens the canes very greatly. The symptoms on the fruit are very much like those on the canes. The spots often have reddish edges. The diseased canes should be cut out as soon as they appear. In addition, spray as for black rot.

Lettuce.

GRAY MOLD: The disease first becomes apparent by reason of the wilted edges of the leaves. Later the affected leaves may droop and die, becoming covered with a dirty, brownish gray fuzz. Proper cultural methods and care of the greenhouse will generally prevent the appearance of the disease. Good ventilation and a fairly constant temperature, which must not be too high, are essential.

WILT: Healthy lettuce in the greenhouse may succumb to this wilt in a single day. Affected leaves appear as though they had been suddenly plunged into boiling water and then taken out again. A dense, white growth of fungus threads appears on parts which have collapsed. The fungus produces storage organs which persist throughout the winter, causing infection the next year. All affected portions should be removed in order to prevent the formation of these organs. The same general sanitary precautions mentioned under gray mold should be taken. In case the soil becomes infected, it should be disinfected with formalin used at the rate of 1 pound to $1\frac{1}{2}$ gallons of water; it may be necessary to change the soil entirely.

Melons.

See Cucumber.

Onion.

BLIGHT—DOWNY MILDEW: Warm, moist weather is especially favorable to the spread of the disease. The tips are first attacked, presenting a water-soaked appearance, which is followed by a fuzzy outgrowth. Later the plants may collapse entirely, thus preventing the formation of normal bulbs.

Crop rotation, clean culture and spraying will prevent the disease. If it has never appeared before, it may not be necessary to spray before the disease appears, but upon the first indication of its appearance 5-5-50 bordeaux should be applied. One spraying may or may not be sufficient, depending on weather conditions.

SMUT: The smut persists in the soil, so is particularly liable to attack seedlings upon which it causes the formation of black, dusty patches of spores. Rotation is beneficial as is soil treatment with lime used at the rate of about 100 bushels per acre. Treating seed with formalin at the rate of 1 pound to 30 gallons of water is also beneficial.

Pea.

See Bean.

Plum.

1. PLUM CURCULIO: (See *pluni curculio* under *Apple*).
2. SCALES: (Same as under scale on *Apple*).

BLACK KNOT: This disease is prevalent on both wild and cultivated plums and cherries. The first indication of its presence is usually the development on young twigs of velvety, greenish or olive colored swellings. These later in the season become black and brittle. Not only young twigs, but also larger branches may become affected. The branches may be killed on account of the interference with the transportation of nourishment, or their vitality may be lessened. Infection probably takes place largely through wounds and abrasions, so all of these should be carefully avoided. Further, the disease spreads most rapidly while the knots are still young, so that careful pruning before they have had time to develop is necessary. If any have been missed, they should be removed later. Pruning alone, however, is not sufficient to control the disease, since it occurs also on wild plums and cherries. Spraying should also be practiced. The first application should be made in the late winter or early spring while the trees are still dormant, another should be made when the buds begin to swell, while the others may be made as necessity demands. For the first spraying a

6-6-50 bordeaux mixture should be employed, but this would be almost sure to injure the foliage on the trees later in the season. A 3-4-50 mixture of bordeaux is sometimes used without foliage injury resulting, but even this mixture may in some seasons be injurious. Even the weaker solutions proved injurious in experiments conducted by the Pathology Department in 1910. Although its worth on plums has not yet been absolutely demonstrated, self boiled lime sulfur has given much promise and should be tried.

BROWN ROT: Although brown rot is especially destructive on fruit, it occurs also on leaves and twigs, causing a blighted appearance and finally killing them. The fruit is more especially susceptible in the later stages of its development, moist weather being very favorable to the spread of the disease. Small, brownish spots first appear; these enlarge rapidly until the entire fruit may be covered. Upon the surface of the fruit brown patches of spores appear; these spores may be blown long distances, thus spreading the disease. The diseased fruits finally shrivel and dry, often remaining on the tree indefinitely. Infection in the spring is caused largely by these mummied plums, which should, of course, be destroyed.

Spraying should be carried on as for black knot; the self boiled lime sulfur mixture has proven effective in controlling the same disease on peach, and will probably prove efficient when used on plums. Naturally, since plums are more liable to become infected after they are at least half grown, spraying should be continued until late in the season.

FIRE BLIGHT: (See *Apple*).

PLUM POCKET: The fungus attacks the fruit, destroying the pit and converting the entire fruit into a hollow, bladder like sack which later falls from the tree. Twigs may also be infected, and it is supposed that the disease hibernates mainly in this way. The disease apparently does not spread very rapidly, so that pruning out and destroying affected parts, together with the spraying for brown rot and black knot, will help keep it in check.

POWDERY MILDEW: (See *Apple*).

SCAB: Dark brown, scabby spots appear on the surface of the fruit, especially in a rainy season. The disease will yield to the treatment given for brown rot.

SHOT HOLE: Very numerous, rather small, brown spots ap-

pear on the leaves. These later become dry, and the dried portions may fall out, leaving the leaves with the appearance of having been riddled with shot, whence the common name. The chief damage done is in the enormous decrease of leaf surface and the defoliation of the tree. It has been found that 2-4-50 bordeaux or 8-8-50 self boiled lime sulfur will effectively control the disease if spraying is begun early and continued throughout the season at intervals of about two weeks.

COMBINED TREATMENT FOR INSECTS AND FUNGUS PESTS:
Lime sulfur wash in the dormant season. Arsenate of lead and lime sulfur (self boiled) as the buds begin to swell. Repeat at intervals of two weeks until fruit is ready to harvest.

Potato.

COLORADO BEETLE: This striped pest hibernates in soil. As the potatoes show above ground the beetles are on hand to lay the yellow patches of eggs on the underside of the leaves. The greasy looking grubs are the ones that do the damage. An arsenical insecticide will kill them easily, especially if the spray is applied while the larvae are still small.

EARLY BLIGHT: The disease is confined to the leaf, upon which grayish, dry spots are produced. Usually the spots are characterized by the presence of concentric circles. Although the tubers are not affected, the effect on the leaves may be so serious as to very greatly diminish the leaf surface, thus making it impossible to form normal tubers. In dry seasons considerable loss may result if the vines are not properly sprayed. Control consists of proper spraying with bordeaux; when the plants are young, a 4-4-50 mixture should be used, but, after the first two sprayings, a 6-6-50 mixture may be used. The idea is to keep the vines covered with bordeaux from the time they are about six inches high until the end of the season. It is uncertain, at the present time, whether or not in Minnesota it would pay to spray to control this disease alone.

LATE BLIGHT: Late blight has, fortunately, not yet become serious in this state, except when the weather in August is exceptionally wet. The leaves and tubers are both attacked; on the leaves the disease appears first on the edges, blackening and drying them, while on the tubers dark, sunken spots are first developed, followed later by a dry rot or a soft, foul smelling rot which may continue

after the tubers are stored. Only clean, healthy tubers should be selected for seed, and spraying should be conducted as for early blight, except that when spraying for late blight alone, it may be begun later in the season.

SCAB: Affected potatoes show rough, corky patches which may, in severe cases, be cracked. The yield may be somewhat affected, but a greater loss is due to the decreased value of potatoes. It is necessary to remember that beets and turnips are susceptible to the same disease and that the disease persists not only on the tubers, but also in the soil. No susceptible crop should be planted on infected land for at least three years and preferably longer. Seed potatoes should be soaked for two hours in formalin used at the rate of 1 pound to 30 gallons of water. The tubers may then be dried, cut and planted. They should not again be brought into contact with anything which contained them before they were treated. Thirty gallons will usually treat about 45 to 50 bushels of potatoes. Corrosive sublimate may also be used, but, on account of its poisonous nature, is not so desirable as formalin.

TIP BURN: This is a disease which is not induced by any parasitic organism. The tips of the leaves dry and break off during hot, dry weather, especially if the crop is on light soil.

WILT—INTERNAL BROWN ROT: The disease is caused by a fungus which may live in the soil and gain entrance through the roots. The vines wilt, and, when pulled up, the roots usually break off very easily. The disease may be in the tubers at harvest time without showing conspicuous symptoms. However, when stored in warm places where considerable moisture is present, it may spread very rapidly, at first forming a yellowish or black ring near the stem end; and later the entire interior may be converted to a dry, shrivelled mass. Bacteria also very often gain entrance and aid in the rotting process. Potatoes from wilted vines are very liable to be infected, so they should be examined and if they show a brown discoloration beneath the surface of the stem end, they should be used at once, as at this stage they are not unfit for eating. In any case, tubers should be stored in a dry, cold place.

In controlling the disease, affected vines should be removed and destroyed, no affected tubers should be used for seed, and crop rotation should be practiced. It is not definitely known how long soil will remain infected, but it is probable that several years will be

necessary to remove danger of infection from this source. It is important in planting seed to be careful to get clean seed.

WILT—BACILLOSE: The symptoms in the field are somewhat like those just given for internal brown rot. The leaves dry, and the stems and tubers become yellowish or black, exuding a soft, pus-like substance when broken. The disease is spread largely through the agency of insects, so it is especially important to guard against them. The same precautions regarding storage, soil and planting, which were mentioned under internal brown rot, apply here.

COMBINED TREATMENT FOR INSECT AND FUNGUS PESTS: Paris green and bordeaux mixture when plants are six inches high. Repeat at intervals of two weeks during the growing season.

Radish.

MAGGOT: This is a very hard insect to combat. The adult insect looks very much like a house fly. The eggs are laid on the soil near the base of the plant, or on the base itself. Early planting and excess of seed are the best preventives. But see article on page 55.

CLUB ROOT: (See *Cabbage*).

WHITE RUST: Upon radish leaves, especially in the greenhouse, smooth, white blisters may appear on the leaves. The flowers and pods may become swollen and otherwise misshapen. All refuse from diseased parts should be destroyed.

Raspberry and Blackberry.

ANTHRACNOSE: This fungus produces on the young canes the familiar purplish spots. Later in the season the spots become grayish in the center, remaining purple around the border. As the spots increase in size, they may girdle the cane, eventually killing it on account of interference with the water supply. Leaf petioles, the veins of leaves and the leaf blades may also become infected. The berries produced by anthracnosed canes are usually small and dry, on account of their premature ripening.

Raspberries should not be grown on the same soil more than three years if the disease is troublesome. The affected canes should be cut out and burned. Resin bordeaux may be applied early in the season, but, alone, it will not prevent the disease.

CROWN GALL: Crown gall is a bacterial disease, producing on

the roots of raspberries and other plants the well known swellings or galls. From its very nature it would be extremely difficult to control when once established. All affected plants should be pulled up and burned. Only healthy nursery stock should be planted on land which has not recently grown raspberries or blackberries. From the most recent researches on this disease it seems possible that raspberries may become infected from affected apple trees.

LEAF SPOT: Numerous small, light colored spots, with darker borders, often appear. In the center of the spots small black dots are often visible. Usually the disease is not serious, and the value of spraying is not known.

RUST: The rust appears in its most conspicuous stage as bright red patches on the lower side of leaves, distorting and rendering them worthless. The fungus threads may live in the canes for a number of years, so that spraying is of value only in preventing spread to other plants. All affected parts should be removed and burned.

Shrubbery.

Plant lice often attack the leaves of shrubs, but any contact insecticide, like a soap solution, or nicofume will keep them in check.

"RED SPIDER": These little pests are very bad in a dry season. Spraying with ordinary water will keep them in check.

Squash.

See Cucumber.

Strawberry.

LEAF SPOT: The common large leaf spot, with a purplish border and lighter colored center, is usually very prevalent. It may be controlled by spraying with bordeaux once before the blossoms open and once or twice after the fruit is picked. In the late fall or early spring, the leaves may be cut off and then burned. See Spray Calendar, page 174, for insects.

Sweet Peas.

PLANT LICE: As in the case of shrubs the lice on sweet peas can be kept in check by soap solutions, tobacco products or ordinary water.

Tomato.

WORMS: These are larvae of a large moth, often called humming bird moth because of its habit of hovering over flowers and

sucking the nectar therefrom. It flies usually toward evening at dusk. Usually the larvae are not in sufficient numbers to warrant spraying. Hand picking will keep the pests in check.

LEAF SPOTS: A number of leaf spots occur on tomato, but they have not been serious in this state. Spraying with bordeaux will prevent them, if begun about ten days after transplanting and continued at intervals of about two weeks.

POINT ROT: The point or blossom end rot causes great damage in dry seasons. It appears on the blossom end of the fruit as sunken, brownish spots which may increase rapidly in size until the entire fruit is rotted. The cause of the disease has not been fully worked out, but it is known to be most prevalent on light soils during hot, dry weather. Spraying is of little value; sub-irrigation gives some relief.

RIPE ROT: This causes the black rot so common on the ripe fruit. Spraying for leaf spot smay prevent its appearance to a certain extent. The vines should be carefully trained so as to permit of sufficient aeration.

Turnip.

BLACK ROT: (See *Cabbage*).

CLUB ROOT: (See *Cabbage*).

SCAB: (See *Potato*).

SPRAYING MACHINERY.

An individual may understand thoroughly all about insecticides and fungicides and their application, and yet unless he is the right kind of man, or has the right kind of machinery to put the material on the plant in proper form, his knowledge avails him nothing. A spray pump may be capable of applying the spray correctly and economically for a period in one orchard, and not be the right kind for another orchard. Again, one kind of pump may suit one orchard, and good, clean fruit be the result, though perhaps the pump is not as good as that of his neighbor, who sees no good in spraying because his fruit is spotted or worm eaten. With the present day advance in all kinds of machinery, it often pays a man to practically give away an old machine for a new one of more efficient pattern which may be better suited for the work in hand. Spraying, therefore, is a question of individuality and spraying machinery.

For orchard work, it is never advisable to purchase anything smaller than a barrel pump. A good barrel pump will last a life time, and can be used for purposes other than spraying, such as white-washing, disinfecting, etc. Always wash the spraying apparatus out with water after spraying or white-washing and oil and clean up all parts before putting away for winter.

When an orchardist has a sufficient number of trees to require five or six barrels of liquid for one spraying, it is advisable to purchase a large tank, holding 200 to 300 gallons and a double-acting sprayer; or better, if he can afford it, a gasoline sprayer.

Some essentials of a good spraying apparatus are:

1. The pump should be brass lined to prevent corroding or rusting of parts.
2. The pump must have a sufficiently large air chamber to keep the pressure uniform, one that will, with comparative ease, keep, with two leads of hose in operation, a pressure of at least 150 pounds.
3. As the principal ingredient in many of the insecticides and fungicides is the fine material held in suspension, there must be perfect agitators that will keep the liquid in constant motion.
4. The nozzle must be the best that is suited to the occasion. The nozzles of the "Bordeaux" type are not very satisfactory in ordinary usage. The "Vermorel" gives an excellent fine spray, but often is misty too soon after leaving the nozzle. The larger type nozzles, like the "Mistry" are more satisfactory for much of the orchard spraying.
5. Another very important point in spraying is to have a good hose. Often a poor or worn-out hose causes more trouble than all the rest of the apparatus put together. Good hose bands to hold the hose on the couplings, and long hose couplings are essential. A short hose coupling is often more trouble than it is worth.
6. Bamboo extension rods with cut offs at the lower ends are necessary in orchard spraying. The rod inside the bamboo is made either of iron, brass or aluminum. The latter are lighter to handle, and when properly made are excellent. Extension rods can be obtained from eight to

SPRAY

Plant.	Pest.	Spray.	TIME.
Apple.	Codling moth.	Arsenate of Lead (3-50).	First Time. Just after the blossoms fall.
	Scale Insects.	Lime Sulphur. (Boiled.)	After the leaves are lost in fall.
	Curculio (Plum).	Arsenate of Lead (3-50).	Just as the buds are breaking.
	Scab.	Lime Sulphur. (Self boiled).	Before blossom buds open.
	Bitter rot.	Bordeaux mixture.	When apples are $\frac{2}{3}$ grown.
Asparagus.	Rust.	Resin Bordeaux mixture.	After crop is off.
	Beetles.	Arsenate of lead.	After crop is off.
Cabbage. Cauliflower.	Cabbage worm.	Arsenate of Lead (3-50). Plus resin lime mixture.	Whenever the worms appear.
Cucurbits.	Mildew.	Bordeaux mixture.	Middle of July.
	Cucumber beetle.	Arsenate of Lead (3-50).	As soon as insects appear.
Currant. Gooseberry.	Currant worm.	Arsenate of lead or Hellebore.	When insects appear.
	Mildew.	Bordeaux mixture or Potassium. Sulfid (Liver of Sulphur).	Before leaf buds open.
Grape.	Mildew.	Bordeaux mixture.	Before blossoms come out.
	Leaf hopper.	Some miscible oil or kerosene emulsion.	As soon as possible after their appearance.
Plum.	Brown rot.	Bordeaux mixture or lime sulphur.	Just before buds break (Bordeaux).
	Plum pocket.	Copper sulphate and Bordeaux mixture.	Copper sulphate, before any growth starts in spring.
	Curculio.	Arsenate of Lead.	Same as for apple.
Potato.	Scale Insects.	Lime sulphur (boiled).	Same as for apple.
	Blight.	Bordeaux mixture.	When plants are a few inches high.
Raspberry. Blackberry.	Beetle.	Paris green (1-50), or arsenate of lead (4-50).	As soon as beetle eggs hatch.
	Anthracnose.	Bordeaux mixture.	Before leaves open.
Shrubbery.	Red Spider.	Water or some tobacco decoction.	As soon as first noticed.
	Powdery mildew.	Ammoniacal Copper Carbonate or Potassium Sulphid.	Spray as soon as leaves appear.
Strawberry.	Leaf roller.	Arsenate of lead.	Early in the growing season.
	Leaf Spot.	Bordeaux mixture.	Before blossoms open.
Sweet Pea.	Plant lice.	Soap solution or nicotine liquid.	As soon as noticed.
Tomato.	Tomato-worms.	Arsenate of lead (3-50).	Apply when worms appear.

CALENDAR

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TO SPRAY

Second Time.	Third Time.	Fourth Time.	Remarks.
10 days later.	Last of July.	10 days later.	The first spraying is the most important and should be a drenching spray forcing the liquid into the calyx cups.
Before buds burst in spring.			Trees should be thoroughly covered.
When the fruit has set.	10 days later.	One month before harvesting.	
After blossoms drop.	10 days later.		
10 days later.			
2 weeks later.	2 weeks later.	2 weeks later.	Two or three sprayings, usually are all that are necessary. The tops should be burned after the first freeze in the fall.
			Some shoots left larger than others will attract beetles to breed there. Destroy these traps.
Repeat when necessary.			The arsenical used in soapy water will make the poison stick better to the leaf. There is practically no danger in using Paris green or arsenate of lead on cabbages, one reason is because of its method of growth. With cauliflower greater care to be taken if plant is heading.
10 days later.	10 days later.	10 days later.	For larvae on roots, use Tobacco dust or decoctions.
Repeat when necessary.			When berries begin to turn it is better to use Hellebore.
After blossoming.	10 days later.	10 days later.	In first sprayings use Bordeaux mixture. At third spraying Liver of Sulphur is best.
When fruit has set.	2 weeks later.		
2-3 weeks later when leaves are grown (Lime S.)	2 weeks later (Lime Sulphur).	2 weeks later (Lime Sulphur).	Destroy all mummies.
Bordeaux mixture after growth starts.			Remove 6 inches from ends of all twigs in fall and burn.
2 weeks later.	2 weeks later.	2 weeks later.	Keep up every two weeks during growing period.
Repeat when necessary.			Cutting out diseased canes and burning is the essential part.
On young canes a weak Bordeaux mixture (2-3-50) 2 weeks later.	Same 2 weeks later.		Water sprayed on plants having red spiders is as effective as any spraying compound.
5 or 6 days later.	10 days later.		
10 days later.	10 days later.	If necessary, 10 days later.	
3 weeks later.			
10-14 days later.	10-14 days later.		Spray should be very fine and put on forcibly. A spray of water alone is often very effective.
4-6 days later.			Hand picking is ordinarily all that is necessary.

fourteen feet long, but it is not often advisable in this state to purchase one over ten feet.

7. A *necessity* when spraying compounds are used is a good strainer. A fine mesh brass screening set at an angle in the frame of a box is the simplest and best.

Cost of Spraying.

The cost of spraying varies in different localities, depending upon wages, the topography of the land, with the size of the spray machine, the size of the trees, the distance from water used in the spray material, etc. The cost will vary between the different kinds of large and small outfits, from five to fifteen cents per tree for each spraying.

The following is a list of companies to whom the prospective purchaser may write for catalogues and prices.

Spraying Machine Manufacturers.

American Sprayer Co., Minneapolis, Minn.

Barnes Mfg. Co., Mansfield, Ohio.

Bean Spray Pump Co., Cleveland, Ohio.

Binks Spraying Machine Co., Chicago, Ill.

Brandt Manufacturing Co., Hastings, Minn.

E. C. Brown Co., Rochester, N. Y.

Cushman Sprayer Co., Lincoln, Nebr.

Dayton Supply Co., Dayton, Ohio.

Deming Co., Salem, Ohio.

R. H. Deyo & Co., Binghampton, N. Y.

W. & B. Douglas, Middleton, Pa.

Fairbanks, Morse & Co., St. Paul, Minn.

Field Force Pump Co., Elmira, N. Y.

Friend Mfg. Co., Gasport, N. Y.

Gilson Mfg. Co., Port Washington, Wis.

Goulds Mfg. Co., Seneca Falls, N. Y.

Hardie Mfg. Co., Hudson, Mich.

Hurst Mfg. Co., Canton, Ohio.

International Harvester Co.

Latham & Co., Sandusky, Ohio.

Leggett & Brother, 301 Pearl St., New York City.

Morrill & Morley, Benton Harbor, Mich.

F. E. Myers & Bro., Ashland, Ohio.

The New Way Motor Co., Lansing, Mich.

Niagara Sprayer Co., Middleport, N. Y.

Olds Gas Power Co., Lansing, Mich.

Pierce Loop Co., Northeast, Pa.

Splitstoson Mfg. Co., North Branch, Minn.

Spramotor Co., Buffalo, N. Y.

Wm. Stahl Sprayer Co., Quincy, Ill.

Insecticide and Fungicide Manufacturers.

Ansbacker & Co., 253 Broadway, New York City.

Bowker Insecticide Co., 43 Chatham St., Boston, Mass.

Fergusson Bros., 109 Chestnut St., Philadelphia, Pa. (Copper Sulphate).

Good, James, 934-936 N. Front St., Philadelphia, Pa., (Fish oil soap).

Grasselli Chemical Co., 172 E. 5th St., St. Paul, Minn.

Hemingway's London Purple Co., 133 Front St., New York City.

Kentucky Tobacco Produce Co., Louisville, Ky.

Fred. L. Lavanburg, 100 William St., New York City.

Merrimac Chemical Co., 33 Broad St., Boston, Mass.

Niagara Spraying Co., Middleport, N. Y.

Sherwin-Williams Paint Co., Minneapolis, Minn.

Talmadge, Geo. E., Inc., Madison, N. Y. (Aphine).

Taylor, E. R., Penn Yan, N. Y. (Fuma Carbon bisulfid).

Thomsen Chemical Co., Baltimore, Md., New York.

Thum O. & W. Co., Grand Rapids, Mich.

Vreeland Chemical Co., 50 Church St., New York City.

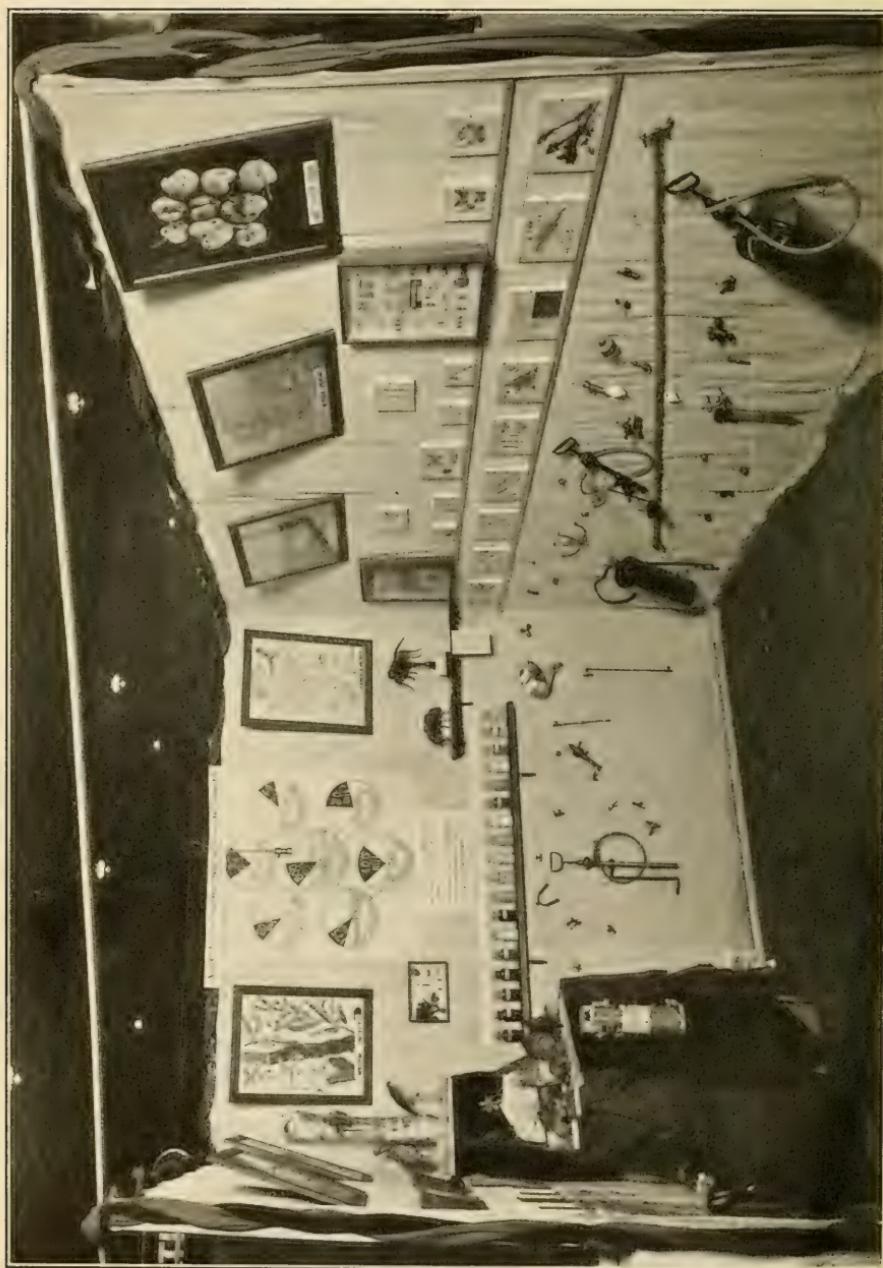


Fig. 85. Our exhibit at the first Conservation Congress, St. Paul Auditorium, March, 1910.

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